FARM BUILDINGS
AND BUILDING CONSTRUCTION
IN SOUTH AFRICA

Fig. 1.—Plan and elevation of steading.

FARM BUILDINGS

AND

BUILDING CONSTRUCTION IN SOUTH AFRICA

A TEXT-BOOK FOR FARMERS, AGRICULTURAL
STUDENTS, TEACHERS, BUILDERS, ETC.

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WITH A FOREWORD BY

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FOREWORD

FARM buildings and what are generally known as "permanent improvements" to farms, such as water-supply, drainage, fencing, roads, shelter-belts, wood-lots, and so forth, are, as Mr. Cleghorne rightly intimates in the preface to this book, matters of the first importance to owners or occupiers of land. The necessity for certain buildings and other works of an engineering character on a farm is of course evident to everybody connected with land, for, without them, farming except of the most primitive type would be impossible, but probably few people—even experienced farmers—fully realise the immense influence the laying-out and development of a farm has upon the quantity and quality of the produce obtained from it or on the cost of working it. Unless a farm has been laid out and subsequently developed so as to permit of the carrying on to advantage of the style of farming for which it is best adapted by the soil, climate, and other factors affecting agriculture, it will obviously be impossible to make the best of it.

Owing to the manner in which they occur, the benefits arising from a well-selected and developed farm, or the losses occurring from the reverse, are apt to escape immediate attention, but they are none the less real, and the fact of the arable land being cropped to a little better advantage, or the stock thriving a little better, or the carrying capacity of the veld being slightly increased, or of economies being effected in manual and animal labour, or in various other directions, may mean all the difference between profit and loss on the year's working.

In South Africa the early settlers devoted great attention to the selection, laying-out, and development of their farms, and particularly to the location and designing of farm houses and buildings, and the beautifying of their surroundings, as may be seen from the distinguished old homesteads still happily remaining in the neighbourhood of Cape Town.

Unfortunately, the care and taste displayed by the original settlers and

their immediate descendants were not maintained by their successors, and, until recently, with the exception possibly of minor irrigation schemes, farm engineering in South Africa has been greatly neglected.

Under the circumstances prevailing before the opening of the mines, this neglect was not greatly felt or much to be wondered at, but, since that date, profound changes have occurred in the farming industry, due partly to local causes and partly to influences that have affected, and are affecting, agriculture throughout the world. Practically the whole of the country suitable for farming has been apportioned into farms, land has greatly appreciated in value, and labour is dearer and more difficult to obtain; improvements in means of communication and transport have brought farmers into touch and consequently into competition, not only with their fellows in this country, but with farmers throughout the world.

Further, the cost of farming and the personal expenses of the farmer and his family have greatly increased, and whereas formerly the needs of a farmer were mainly supplied by the farm, they now extend far beyond what it can produce, and though of course the thrifty man will always make use of home-grown produce, the modern farm is really more of a factory than of an agency for the subsistence of the farmer and his family. This being so, farmers must move with the times, and, like managers of factories, employ every means within their power to promote efficiency and reduce waste.

Unfortunately, the erection of fences and buildings and of the majority of permanent improvements is an expensive business, and it is easy to make mistakes and waste money over them. On the other hand, much can be done by the exercise of thought and ingenuity to reduce the cost of them, and, from every point of view, it is desirable that farmers should study the subject carefully, so that they may understand exactly what is needed to put their farms into good shape and how best to set about doing so.

For large engineering works professional assistance should be obtained, but most of the works required upon a farm are quite within the scope of farmers themselves.

This book is a valuable contribution to an important subject, and should prove exceedingly useful to farmers and to students in agricultural colleges.

It has been written after several years' study of the conditions

obtaining in South Africa, and forms a welcome addition to the small but growing collection of books, dealing with agricultural subjects, produced in this country, but, though primarily intended for South Africa, it contains information that cannot fail to be of value to farmers wherever they may be, and it is to be hoped that it will meet with the success it deserves.

F. B. SMITH,
*Secretary for Agriculture,
Union of South Africa.*

PREFACE TO THE SECOND EDITION.

THE first edition of this work has been very favourably received, and there is now a demand for a second. Some new matter has been added in the form of an appendix, consisting of illustrated chapters on Thatching and a Small Farm Dairy; also two additional lay-out plans of steadings. The author has some reason to believe that the book has served a useful purpose in the past, and trusts that the second edition will receive a no less favourable reception at the hands of the public, and in particular of the farmers, than did the first.

W. S. H. CLEGHORNE.

POTCHEFSTROOM,
1921.

PREFACE TO THE FIRST EDITION

"FARM BUILDING CONSTRUCTION" is a subject of prime importance, especially in a country like South Africa, much of which has been settled in comparatively recent years, and it rightly occupies an outstanding place in the syllabuses of the Agricultural Colleges of the Union of South Africa.

In writing this book the author has endeavoured to keep in view the needs of farmers, as well as those of agricultural students and teachers. The work, it is hoped, may also prove useful to builders, and may apply, to a great extent, to other countries with a climate similar to that of South Africa. The appendix is inserted chiefly for the purpose of completing the work from the point of view of lecturers, and of advanced students reading for the degree of B.Sc. in Agriculture of the Cape University.

The author has to thank the following gentlemen for information and willing assistance: Messrs. F. B. Smith, Secretary for Agriculture, Union of South Africa; Alex. Holm, Under Secretary for Agriculture, Union of South Africa; E. E. Downing, Rosetta, Natal; Jas. J. McColl, Government Wool Expert, Natal; and the following members of the Staff of the School of Agriculture, Potchefstroom: E. J. Macmillan, B.S.A., Principal; E. Holmes Smith, B.Sc. (Edin.), Lecturer in Botany; J. B. Fisher, N.D.D., Lecturer in Dairying; and G. R. Peschel, late Instructor in Carpentry.

The publications of the following firms have also been drawn upon: Messrs. White's South African Cement Co., Ltd., description and illustrations of reinforced concrete fencing; Messrs. Young and Co., Westminster, London, cow-byre fittings; Messrs. the Loudon Machinery Co., Iowa, U.S.A., Litter Carriers; Messrs. John Wallace and Sons, Ltd., Graham Square, Glasgow, liquid manure pump.

In writing the chapter on cement concrete, "Concrete, Plain and Reinforced," by Taylor and Thompson, has been referred to.

W. S. H. CLEGHORNE.

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FARM BUILDINGS AND BUILDING CONSTRUCTION IN SOUTH AFRICA

CHAPTER I

INTRODUCTION—GENERAL LAY-OUT, ARRANGEMENT, AND DESIGN OF FARM BUILDINGS.

THE principal object of the author in writing this book was to produce a work co-ordinating building construction, as practised in South Africa, with the design and erection of farm buildings for that country.

It has been endeavoured to make the drawings a feature of the book. They are practically all original, and, wherever possible, conventional perspective or isometric views have been given, which should prove of value to those who are not accustomed to reading ordinary two-dimensional drawings.

It is hoped that the resulting work will prove useful not only to farmers, builders, etc., but also as a text-book for students attending agricultural colleges, and for teachers.

Existing books dealing with building construction, and also those on farm buildings suitable for countries other than South Africa, are of comparatively limited application to the latter country. This will be made clear by a few instances, *e.g.*—

Corrugated galvanised iron, though ugly and possessing many serious demerits as a building material, yet plays a large part in the construction of farm buildings in South Africa. Its uses and applications have therefore been treated in this book with a considerable degree of fulness, whereas it is scarcely mentioned in existing British and American text-books.

Again, corrugated iron as a roof-covering calls for full treatment in a book such as this. Further, the design of roofs suited to the South African climate is quite different from that of roofs for British or

American conditions, since the latter must be strong enough to sustain heavy snow loads in addition to weighty roof-coverings such as slates or tiles. Roofs in South Africa, on the other hand, are seldom or never subjected to snow loads, and usually carry light corrugated iron as a roof-covering.

The influence of climate is again apparent in the provisions necessary to secure good ventilation. In South Africa ventilation is comparatively simple, there being no necessity for elaborate systems such as the "King" system or the "Rutherford" system employed in cold parts of North America where, in winter, efficient ventilation has to be provided for while a very low temperature prevails outside of the byre or stable.

In the parts of America mentioned, it often happens that animals cannot be taken outside to drink, and therefore a water service is commonly laid on to each stall in the cow-byre, and the same arrangement is usually provided in the horse stable as well. In South Africa, however, all that is really necessary in the way of drinking facilities is a watering trough outside, preferably situated in a yard into which the animals can be turned when they require to be watered.

In laying out a steading there are many desirable features to be aimed at. In any one particular case some of these features may be unattainable, and some contradictory, so that each case must be considered on its own merits in order to take advantage of as many good features as possible.

If a main road runs through the farm, the house and steading might be situated sufficiently near it for convenience, provided this position is also suitable from the points of view of the general working of the farm, healthiness, water-supply, etc. The homestead, however, should not be right on the highway, but should stand a little back from it so as to avoid dust, risk of infection from live-stock passing along the road, etc. A good approach drive should lead from the highway to the house. This drive should be laid out as tastefully as possible; for example it is not desirable to have it pass close to the piggery. The dwelling-house should be situated conveniently near to the steading, but yet far enough off to minimise nuisances, such as flies, bad odours, etc. The steading should be placed, relatively to the house, so that the prevailing winds carry stable odours away from the latter. It is advisable that the windows at one side of the house,

including that of the master's office, should command a good view of the steading.

The site for the homestead should be high, dry, and healthy, and near to a source of water supply. If there be any suspicion that the ground of a proposed site may, at some seasons, become water-logged, such a site should be abandoned. In doubtful cases it may be advisable to test the site by sinking trial holes at different parts of it, and observing how long the water surface in these holes takes to sink to a depth of 2 feet from the surface of the ground, after the occurrence of heavy and continued rain. If trial holes be sunk in the dry season, and water be reached at 3 feet depth or less, it will probably be advisable to abandon the site. Farm buildings and dwelling houses should never be located immediately below an irrigation canal.

A gravelly, shaley, or rocky subsoil is the best to build upon. Very sandy or clayey soils should be avoided.

A slight ground slope, about 1 in 50, is the most desirable, as it facilitates drainage without making the floors and buildings difficult to construct, as would be the case on a steeper slope.

Sunlight is an excellent germicide, and buildings in which animals are housed should be aligned so that the sun can shine freely into them at some period, or periods, of the day. Thus a cow-byre running with its length more or less north and south, and provided with windows along each side, would be penetrated by the rays of both the morning and afternoon sun. If, however, animals are tied up in stalls during the day, care should be taken that some part of the head of the stall is always in shadow, so that the animal need not subject itself to direct sunlight falling on its eyes. Further, any surfaces from which, if white, the glare of reflected sunlight would impinge on the animal's eyes, should be coloured either grey or some other neutral tint.

Avoid where possible having the doors, of buildings which house animals, facing the direction from which cold winter winds blow.

In colder parts of the country the site for the farm buildings should be chosen so that, if possible, the homestead will be sheltered from these cold winds, without cool and refreshing summer winds being impeded. If natural shelter does not exist, a belt of trees may be planted for this purpose. Judicious tree planting, with due regard to coolness and not burying the buildings in trees, will in most cases improve the appearance of both steading and dwelling-house.

It is probably not advisable for a farmer to rush up permanent buildings immediately following his taking up a farm. It is better for him to use either existing old, or else temporary buildings for some time until, by daily observation and experience, he is at last able to come to some definite conclusions as to the best site for the new buildings, and their best arrangement to suit the working of his farm.

In few cases will the farmer erect all the necessary buildings at once. If he does not do so he should, nevertheless, start to erect such buildings as he decides to construct at the moment, in accordance with a definite plan of the homestead as it will be when complete. This plan should not only be thought out mentally, but should also be drawn to scale on paper, before any building is commenced. It will then be possible to add to and extend the buildings first erected with as little breaking down of walls, etc., as may be, and the completed homestead will be properly designed, and not the result of hap-hazard additions to the original buildings.

As an example, referring to the steading illustrated in the frontispiece, the farmer may decide to erect the cow-byre and feed-room first of all, for the time being remaining content to use a pit silo, and to store his fodder in the stack. At later periods he might erect the tower silo, engine-room, Dutch barn, bull-boxes, stable, etc., as funds permit and requirements dictate.

While paying due regard to the health of the animals housed, the various buildings of a steading should be arranged as compactly as possible, so as to reduce the labour of attendance, including cleaning and feeding, to a minimum. A compact arrangement will also reduce first cost, and maintenance charges. A striking fault of many South African steadings is the scattered arrangement, or one might almost say lack of arrangement, of the component buildings.

The live-stock should be housed as near to the food-stores, and feed preparation and mixing-room, as possible; indeed the proper placing and arrangement of these feed buildings, relatively to the buildings housing the stock, may be regarded as the chief guiding principle of the whole process of designing. The food-stores themselves ought to be placed in close relationship to each other, and to the feed preparation and mixing room. Thus to the latter apartment, the silos, Dutch barn, and chaff stores should be conveniently arranged and near at hand,

There are some other points which should be borne in mind when planning the lay-out of a steading, such are—

The separate blocks of buildings should be spaced far enough apart to allow of a waggon and span of oxen being driven round each one. It should also be possible to drive a waggon through each yard without difficulty. To allow of this, gates should not be less than 14 feet wide.

The cart and implement shed should be situated conveniently near to the stable. The Cape-cart shed had better be provided with doors so that it can be completely closed in. The open front of the implement shed should face, as much as possible, away from the sun and prevailing rain-bearing winds.

It will often be found advisable to fit sliding doors in outer walls which are in exposed and windy positions. Doors of this type should be fitted between bull-boxes and their adjoining exercise yards; swing doors in such a position would soon be smashed.

The drainage pipes from cow-byres, piggeries, and stables should lead to a liquid manure tank, adjoining the dung-stead, from which, by means of a pump of the chain and disc type, the urine liquid may be lifted at intervals and distributed over the solid manure in the dung-stead so as to soak it, thereby greatly enhancing its manurial value. An objection, however, to this arrangement is that during warm weather flies breed in the dung, and if the dung-stead is situated near to the farm buildings these flies are apt to become a nuisance. One method which has been proposed for overcoming this, is to net in the dung-stead with fly-netting, so that flies cannot gain access to the manure to lay their eggs in it.

The frontispiece (Fig. 1) shows a steading arranged on the principles mentioned. The feed-room (feed preparation and mixing room), and fodder stores, such as silo, Dutch barn, and chaff store, are central. The Dutch barn (not shown) might be placed opposite the silo and feed-room, to the north. It would then be central, and near to a threshing or other machine driven by that belt which, on the drawing, is shown driving the ensilage cutter EC.

The silo discharges into the feed-room by way of the chute C, which passes through the roof of the feed-room. The cow-byre, bull-boxes, and stock-shed are all easily reached from the feed-room. The chaff store is convenient to stable, bull-boxes, and cow-byre.

The arrangement of the machinery is simple, all power being transmitted by belt. The engine-house is cheaply constructed as a lean-to against the silo. E is an oil-engine, or a suction gas-engine might be installed if the power required exceeds eight horse-power. T is the cooling tank for the cylinder-jacket circulating water. This is generally a galvanised, corrugated iron tank, which is better placed outside the engine-room than inside it. The engine drives an overhead counter shaft which extends across the silo end of the feed-room. The broken line, shown in the plan between engine-house and cow-byre, is intended to indicate the edge of a roof sheltering the main-drive belt, the fast and loose pulleys on which it runs, the end-bearing and wall-bracket, and the end of the counter shaft. From the counter shaft the mealie grinding mill, GM, and the ensilage cutter, EC, are driven, the belt of the latter passing through an orifice in the wall of the feed-room. From the second overhead shaft the root pulper, RP (or other machine), and the chaff-cutter, CC, are driven. The ensilage cutter may be used to cut chaff if desired, being placed in the position CC for the purpose. From the counter shaft other machines, if required, might be driven; if this is done it might be advisable to make the feed-room a little larger.

The chaff-cutter elevates, or blows, the chaff into the chaff store through an orifice immediately under the eaves. The ensilage cutter elevates (generally by means of an air blast from a fan) the ensilage into the silo through the filling door in the roof of the silo; this door is shown in the front elevation.

In arranging belt-driven machinery it is as well to keep the following points in view:—

1. The tight or driving side of a belt should, if possible, be the lower. This is because if the slack side is on the top it hangs down on to the pulley rims, and thus the extent of contact between belt and pulleys is increased. On the other hand, if the slack side of the belt is below, it hangs away from the pulley rims, and hence the extent of contact is diminished. It is especially desirable to have the slack side on top in the case of the main-drive belt from the engine.
2. Provided the above condition is satisfied a slightly inclined belt will run more satisfactorily than one which is exactly vertical, *i.e.* in which the centre line of the one shaft is vertically over that of the other.

3. If a belt is too short it gives more trouble in running than it would do if long enough. If much power is to be transmitted the distance between the centres of the driving and following pulleys should not be less than five times the diameter of the larger pulley, and may be as much as 30 feet.

The cow byre provides accommodation for thirty-two cows. Part of the stock shed may be partitioned off to form calf pens. The stock shed is of wood-and-iron construction. The bull-boxes are provided with separate exercise yards. The wall between the bull-boxes and the bull-box feeding passage is a dwarf wall, so that food can easily be thrown over it into the mangers. Liquid manure from the cow-byre discharges into the sumps SS which are connected, by a 6-inch stoneware drain pipe, with the liquid manure tank (not shown).

The stable contains stalls for four horses, and has a harness-room adjoining. The loose box for horses is arranged in such a way that, by erecting a temporary stall division, it can when desired be converted into a stable containing two stalls. For this purpose the mangers are constructed like those in the main stable. Drainage from the horse loose-box and stable takes place into the sump shown, which must be emptied at intervals by baling. This sump may, however, be connected to the pipe which carries the cow-byre drainage to the liquid manure tank.

The sick boxes are isolated at the end of the wing. The party wall separating them from the horse loose-box should extend upwards right to the iron roof-covering, so as to completely isolate them.

The piggery, implement shed, Cape-cart shed, and workshop are all wood-and-iron buildings. The boiler-room, adjoining the piggery, is of brick; in it hot food can be prepared for the pigs. Each pig-house is provided with an exercise yard.

The buildings are arranged, so far as possible, to form the sides of two yards, viz. the main yard and the stock yard. Each of these two yards is provided with a drinking trough, that in the stock yard being a circular one constructed of reinforced concrete. Each yard has two gates, those of the main yard being 14-foot gates so that a waggon and span of oxen can be driven easily through the yard.

It will be noticed from the elevation drawings that the party wall between the bull-boxes and the feed-room passes right through the roof-

covering for a considerable distance. This forms a valuable protection against fire, especially if the door in this wall (at the end of the bull-box feeding passage) be fire-resisting—preferably asbestos covered. By closing this door, one wing of the building may be more or less isolated from the other, and a fire raging in one wing may be prevented from spreading to the other.

While, in accordance with what has already been stated, the plan shown in the frontispiece ought to be regarded as a final plan, which will gradually materialize as different buildings are erected from time to time and as funds and circumstances permit, it is no bad thing to have even these presumed final buildings capable of easy extension without much knocking down of walls, etc. Should such extension be required in the case of the steading illustrated, the extra accommodation can easily be arranged for by extending each wing of the main building. The stock shed and piggeries can also be easily extended towards the south. The silo might be extended upwards till a total internal height of 40 feet, from the floor to the top of the masonry of the walls, is reached. Of course the walls of the silo, as built at first, must be constructed strongly enough to allow of this future increase of height. In certain circumstances it might be considered advisable to build the walls and footings of the feed-room strong enough to allow of an upper storey being added at some future time.

CHAPTER II

BRICKS AND BRICKMAKING

ON nearly all farms earth suitable for the manufacture of bricks can be found.

In South Africa the sun-dried brick is employed to a great extent, but it is much better to make and use the burnt brick; the extra cost of the burning process amounts to only a few shillings per thousand bricks.

Brick Earth.—This is the name given to the earth from which good burnt bricks can be made. A suitable earth has been found to be a loam (*i.e.* a mixture of clay and sand) consisting of about 4 parts clay to 1 part sand. Pure clay is not suitable for brickmaking. It shrinks, cracks, and twists too much while the bricks are being dried and burned. The presence of sand, in about the above proportion, prevents twisting and cracking and lessens the amount of shrinkage; on the other hand, the presence of too much sand makes the bricks weak and easily broken.

In addition to clay and sand, a good brick earth should contain materials which promote partial fusion of the brick earth, and which are therefore called *fluxes*. Lime, iron oxide, and magnesia, are all fluxes. Fluxes increase the tendency to vitrify, thus partially fusing the particles of brick earth together, and producing a stronger brick. Lime, however, must not be present in too large quantities, or it will cause the bricks to fuse and run out of shape. Most brick earths contain magnesia and iron oxide. The latter is the more favourable to the quality of the bricks produced. The presence of iron is indicated by a dark grayish blue colour, in the interior of the finished brick, changing to red at or near the surface.

Earth containing carbonate of lime (limestone, chalk) should be avoided, because this impurity burns to quicklime, which afterwards tends to absorb moisture and so cause disintegration of the brick.

The presence of carbonate of lime in considerable quantity is indicated by effervescence on the brick earth being treated with an acid.

Different brick earths, on being burned, produce different colours; thus a pure sandy clay burns almost white, while the presence of manganese is indicated by a brownish colour. Lime makes the bricks whitish. The coloration produced by the presence of iron has already been discussed. The presence, in the same brick earth, of two or more of the above constituents, produces modifications of the characteristic colours peculiar to each. The coloration is affected to a less degree by the intensity of the heat to which the bricks have been subjected, those near the fires being generally of a darker colour (and harder) than those near the outside of the clamp, on account of the greater vitrification caused in them.

It is seldom that a really first-class brick earth is got from one pit, but often a good result can be attained by mixing the earths obtained from two pits.

A good indication, as to whether or not a brick earth contains a sufficient proportion of sand, is afforded by moulding a few trial bricks and placing them in a shady place to dry. If they crack while drying, the brick earth requires the addition of some sand.

Mixing.—The brick earth, having been dug from the ground and cleared of rubbish and stones, is well mixed or puddled with water, either by a *pug-mill*, or in a small pit by natives wielding shovels, until it becomes quite homogeneous, soft, and plastic.

A pug-mill consists of a vertical cylinder containing flat agitator arms fixed to, and rotating with, a vertical shaft. The surfaces of these arms are set obliquely, so that while mixing they also force the brick earth downwards, causing it to stream slowly through a hole in the side of the cylinder near its lower end. A small pug-mill is usually driven by a horse, or mule, walking in a circular path.

The admixture, during the process of puddling, of a small quantity of coal dust, or fine screened cinders, will assist the subsequent burning. The mixture, after having received its first puddling, is allowed to stand for a few days, and is then re-puddled.

Moulding.—This operation may be performed by hand in wooden moulds, such as that illustrated by Fig. 2. On account of the shrinkage which occurs, the dimensions of the mould must be considerably greater than those which it is desired the finished brick should have.

As the amount of this shrinkage varies for different brick earths, the contraction to be allowed for can only be determined experimentally, for the particular earth being used. The size of an ordinary brick is 9" by 4 $\frac{3}{8}$ " by 3". Roughly approximate allowances

FIG. 2.

for contraction would be $\frac{1}{2}$ inch on the length, a full $\frac{1}{4}$ inch on the width, and a full $\frac{1}{8}$ inch on the thickness.

The mould illustrated is triple, that is it moulds three bricks at a time. The strip of wood which forms the bottom should be at least $\frac{1}{4}$ inch narrower than the inside width of the mould, so as to leave an opening at least $\frac{1}{8}$ inch wide along each side of the bottom. These openings allow the air, which is displaced by the brick earth being pressed into the mould, to escape. The mould illustrated in Fig. 2 is drawn bottom upwards, to show this.

Bricks moulded by hand in this way may easily be provided with a *frog*, or indentation, on one face, by nailing a piece of wood of the required shape and size to the bottom of the mould. The frog forms a key for the mortar when the bricks are built in place.

Bricks may be hand-moulded by either of two methods, called respectively "slop moulding" and "sand moulding," according to the procedure which is adopted in order to prevent the brick earth from adhering to the mould.

In **Slop Moulding** the mould is dipped in water before moulding each set of three bricks. This method is open to the objection that it is apt to cause the bricks to crack and twist while they are drying.

Sand Moulding is the better method; the inside of the mould is sprinkled with fine dry sand each time a set of three bricks is to be moulded.

In this connection it may be mentioned that lining the mould with sheet zinc, or flat galvanised iron, allows the bricks to leave the mould very cleanly and easily.

The brick earth should be thoroughly pressed and kneaded into the mould by hand, and then straightened, or struck off on the upper surface with a "straight-edge" or "strike" till flush with the top of the mould.

Drying.—The mould is then taken up in both hands and carried to a level piece of ground, that has been previously prepared by clearing

off any vegetation, smoothing it, and sprinkling with sand; here the mould is inverted and the bricks are slipped out to form rows as shown in Fig. 3.

The rows of bricks should be protected from sun, frost, rain, and drying winds, by sheets of galvanised iron, tarpaulins, rough grass or

FIG. 3.

ashes, etc., or if they can be placed in an open shed so much the better. The bricks are allowed to lie until hard enough to handle, which will be in one or two days, according to weather conditions.

The bricks are then built up on their edges, in double rows, as shown in Fig. 4, upon a piece of ground which has been previously levelled and

FIG. 4.

prepared. This site should preferably be slightly raised above the level of the surrounding ground. The bricks should be built up openly, as shown, so as to allow of free air circulation among them. If there be any probability of the occurrence of rain, the rows of bricks should be covered with corrugated iron sheets, sacks, or boards, and a channel should be formed in the ground between each double row (see Fig. 4) to carry off storm water.

The best months in which to make bricks are those during which little or no rain or frost is to be expected. If frosty nights are expected, the bricks which are undergoing the preliminary drying process (Fig. 3)

should be well covered with grass or ashes before sunset, and exposed again after sunrise.

When the bricks are dry through and through, they are ready for burning. Their dryness may be tested by breaking one occasionally, and noting by the colour if it is dry right to the heart. The bricks will probably be fit for burning about ten days after having been piled in the double rows shown in Fig. 4.

Burning.—The method of burning most suitable to the farmer, who

FIG. 5.

desires to produce only a relatively small number of bricks for his own use, would be to build the bricks into a *clamp* or stack. A piece of ground having a hard and solid surface, capable of bearing the weight of the clamp without sinking, is selected and levelled. If old burnt bricks are available a layer, or "course," of these may be laid, the bricks being placed close together on their faces, to form a foundation for the clamp (see Fig. 5). If burnt bricks are not available this foundation layer may be dispensed with. If there be any probability of rain the foundation of the clamp should be guarded on its upper side by a good open drain.

Note that all the bricks composing the clamp, with the exception of those forming the above-mentioned foundation layer, are to be laid on edge.

On top of the foundation the first course of "green" bricks is laid. The bricks forming this layer are placed close together (close-packed), without actual cramming, with their lengths at right-angles to the lengths of the bricks forming the foundation course.

The second course consists of rows of bricks laid diagonally, as shown

FIG. 6.

in Fig. 6, with spaces 3 inches wide between each row of bricks. These spaces are filled with small fragments of coal. Round the outside of this course a row, R, of bricks is laid about $1\frac{1}{2}$ inches away from the outer corners of the bricks composing the main mass, and in the space between fragments of coal are placed.

The third course is similar to the second, except that the rows of bricks composing it run in opposite diagonal directions to the rows of the second course, thereby crossing the latter rows at right-angles.

Frequently, especially in the case of small clamps, the double-diagonal or herring-bone arrangement of the rows in each of the second and third courses is dispensed with, the bricks in each of these two courses being arranged in continuous diagonal rows passing straight through the clamp. The rows of the third course still, however, cross those of the second at right-angles.

From now on, each course is commenced about 1 inch in from the edge of the course immediately below, thus giving the clamp a taper inwards towards the top, as shown in Fig. 8.

The next eight courses consist of bricks packed closely together, the bricks in alternate courses being arranged according to Figs. 7 (a) and (b), which show the arrangement at one corner of the clamp. The spaces, S,

FIG. 7 (a).

FIG. 7 (b).

left between the outer bricks and the main mass, are filled with small coal, as shown.

In the twelfth course the rows again run diagonally, with 3-inch spaces between filled with small coal. This course is similar to the second or third course (Fig. 6).

The next seven courses are again close packed, in alternate courses as shown in Figs. 7 (a) and (b), the spaces S being filled with small coal as before.

The twentieth course is again a diagonal course similar to the second, third, or twelfth, the 3-inch spaces between the rows being filled with fragments of coal.

The final nine courses are laid close-packed as in Figs. 7 (a) and (b) alternately, the spaces S being filled with small coal.

While the clamp is being built, fire-places F (Figs. 6 and 8) for kindling-fires are left, and are gradually closed over on top by

"corbelling" the bricks, *i.e.* by allowing each brick to project slightly beyond the brick immediately below it. This projection should not exceed 2 inches at a time.

Instead of being formed as large as shown in the figure, these fire-places are sometimes made much smaller and receptacles for fuel are built up, with a few bricks, outside the clamp. Only part of the kindling fuel then occupies the now reduced fireplace F, the bulk of it being in the outer receptacle, built in front of F. These outer receptacles should be covered in on top by a piece of sheet-iron, or a flat stone, so as to drive the flames from the kindling-fire into the clamp.

If sufficient old burnt bricks are available it is advantageous to build

FIG. 8.—Clamp for coal firing.

up the four sides of the clamp with a 3-inch skin of these built on edge. Bricks from a previous clamp, which have been spoiled in the burning, may be used for this purpose.

The outside of the clamp, with the exception of the top, is now thoroughly plastered with clay or *dagga*, and the kindling-fires are laid and ignited.

When it is evident that the fuel in the clamp is well alight and burning briskly, the ends of the kindling fireplaces are bricked up almost completely, and plastered with *dagga*, and the top of the clamp is covered with a layer of ashes. In this way combustion is prevented from being too rapid. Sufficient air finds its way into the clamp through the small orifices left at the kindling fireplaces, and through cracks

which form in the *dagga* plaster as it dries, in fact it may be necessary to plaster up some of these cracks so as to control the combustion.

The clamp is allowed to burn for four or five days, by which time the bricks should be sufficiently fired. Combustion is then stopped by completely closing the ends of the kindling fire-places, and plastering all cracks, and also the top of the clamp, with *dagga* to exclude air. The clamp is then allowed to stand for about ten days, to cool off, before the bricks are removed.

Wood-firing.—In cases when coal is not available as a fuel, wood may be substituted. Since, when wood is used, the fires must be replenished frequently during the burning of a clamp, it would not be suitable to distribute the fuel throughout the clamp, as has been described for coal. The wood must be concentrated in fuel chambers. A clamp suitable for wood-firing is shown in Fig. 9. The bricks composing it are built close-packed on edge, the lengths of the bricks in any one course crossing the lengths of bricks in adjacent courses at right angles. Two fuel chambers, F, running from end to end of the clamp, are left, being closed over on top by corbelling the bricks. These fuel chambers are packed carefully with fuel,

FIG. 9.—Clamp for wood firing.

while the clamp is being built. The fuel should consist of logs, not less than 4 inches in diameter, with chips underneath for kindling. The sides of the clamp are plastered with *dagga* and a layer of ashes is laid on top. The fires are then ignited, and the ends of the fuel chambers bricked up and smeared with *dagga*, as for coal-firing. The fires must be stoked, at least three times every 24 hours, with logs

cut to about 4-foot lengths. In order to stoke, the ends of the fuel chambers must be opened; they should be re-closed immediately afterwards. The clamp should be kept burning until it shows red-hot at the top. Hard-wood logs from trees such as Wattle, Mimosa, Red-thorn, and some of the Gums, are suitable as fuel.

Quality and number of Bricks to be expected from a Clamp.—On account of unequal firing the bricks burned in a clamp will vary in quality. In general, those nearest the fire, or in the heart of the clamp, are the hardest. Insufficiently burned bricks may be reburned in a future clamp, being placed near the outside thereof.

From the clamp illustrated by Fig. 8, for coal-firing, we might reasonably expect to obtain over 35,000 good bricks or so-called "reds"; while from the clamp described and illustrated (Fig. 9) for wood-firing we might hope to procure nearly 20,000 reds.

Soft bricks may be used for inside or party walls, and in places where little weight comes upon them. Hard-burned bricks should be reserved for foundations, outside walls, and places in which they are called upon to resist great weight.

The bricks forming a clamp should be carefully and evenly laid, so as to insure the production of shapely well-burned bricks.

Tests for a good Brick.—A good burnt brick should be regular in shape, with flat parallel surfaces, and sharp right-angled edges.

It should emit a clear ringing sound when struck against another good brick.

When broken it should show a compact uniform structure, hard and somewhat glassy, and free from air-bubbles.

It should be free from cracks.

It should not absorb more than one-sixth of its weight of water when saturated.

When set *on end* in a hydraulic press it should stand a pressure of 1100 lbs. per square inch before crushing.

It is only after considerable experience, and with the best of materials, that a brick conforming to the above tests can be produced, but no farmer need despair of being able to make a burnt brick strong and durable enough for ordinary purposes.

Sun-dried Bricks.—Sun-dried bricks are made in the same way as burnt bricks, excepting that the burning process is omitted. They can be made of earth consisting almost entirely of clay and sand, without the presence

of the other materials (fluxes) already mentioned, which is necessary for the production of good burnt bricks. *Vlei* ground, with the admixture of a little sand, is often suitable for the manufacture of sun-dried bricks.

A sun-dried brick of large size was extensively employed in building houses in Kimberley, just after the founding of that town, and hence received the name of the "Kimberley brick." The sizes of Kimberley bricks are 12" by 6" by 6", 12" by 8" by 8", and 12" by 9" by 9". They may be used on the farm for building the walls of kraals, etc., where no stones are available. They are formed in single moulds, without bottoms, in the position where they are to be left for drying, as they cannot well be carried in the mould.

CHAPTER III

SITE—FOUNDATIONS AND FOOTINGS—DAMP COURSE

Site.—The site for buildings should be dry and healthy, and free from rotting or fermenting organic matter.

Foundations.—A good foundation is one which will remain equally firm under all parts of the walls of the building. If the foundation soil is hard at one place, and soft at another, the walls borne by the soft part will settle more than those on the hard part, resulting in the formation of settlement cracks in the walls. A site should therefore be chosen where the subsoil is of uniform hardness and texture horizontally.

“Footings” of walls should, if possible, rest on solid or virgin soil, “made” ground being avoided or removed.

An excellent foundation is afforded by deep beds of gravel. The gravel should be disturbed as little as possible while excavating.

Clay containing a large proportion of grit also forms a good foundation, but more nearly pure clay soils should be avoided, because the purer the clay is, the more is it affected by changes in the weather, expanding in wet weather and contracting in dry, to an extent which may unsettle the footings.

If a building is to be erected on a hillside the foundations should be stepped, or “benched,” so that the footings rest on horizontal, and not on slanting, surfaces.

Buildings should not be erected on ground containing ant nests or ant channels.

The foundation trenches should be excavated until a solid layer is reached. In South Africa they seldom need be deeper than 18 inches for single-storey buildings.

The bottom of the foundation trenches should be hard. It may be tested by blows from a tool, when variation of sound will indicate any underlying soft places. Such bad parts should be excavated or, if possible, rammed until hard, indeed it is advisable to ram all over the bottom

of the foundation trenches with a heavy rammer, before commencing to build the footings. If any grave doubt exists as to the solidity of underlying strata, these may be examined by sinking trial pits.

Setting out the Foundation Trenches.—It is most important that the foundation trenches and footings should be set out correctly, so as to give the building accurately squared corners from the beginning.

Cheap farmers' levels are now procurable which are provided with a graduated circle, by the use of which angles can be set out. Such an instrument will be found useful for the purpose under discussion.

Should no instrument of this nature be available, a

FIG. 10.

FIG. 11.

right-angled triangle can be constructed out of three flooring boards as shown in Fig. 10. The flooring boards are nailed together so as to form a triangle, with sides respectively 6, 8, and 10 feet long; the angle contained between the two shorter sides is a right angle.

The triangle is used as indicated in Fig. 11, stretched lines or cords, attached to pegs driven into the ground, being employed to mark out the trenches. It will be observed from Fig. 11 that the pegs are driven well outside of the trenches. If they be placed too near the trenches they are liable to be disturbed during the process of excavation.

Footings.—The term "footing" has been tacitly used, in the preceding

part of this chapter, to denote the lower part of a wall, which is mainly below ground. The footing, in all cases, should be wider than the thickness of the wall itself, so as to distribute the pressure—due to the weight of the building—over a sufficiently large area of ground at the bottom of the foundation trenches.

In farm buildings, in South Africa, the footings are generally of stone built in lime mortar. They may also, however, be constructed of cement concrete (plain or reinforced); or partly of cement concrete and partly of hard-burned blue bricks.

The last mentioned type of footing consists of layers or courses of the best hard-burned blue bricks, each course extending—on each side—slightly beyond the one above it, so as to widen out the footing towards the bottom. This brickwork part of the footing is carried on a cement concrete base, which fills the foundation trench to a depth of from 4 to 6 inches, and projects slightly on each side of the lowest course of brickwork. The brickwork should be rendered, or plastered, with cement plaster to a height of 6 inches above the ground, to protect the bricks against damp.

Should it be necessary to erect a building on a bad foundation, a footing of cement concrete, reinforced by iron or steel bars imbedded in it, will be found the best.

Stone footings should consist of at least two courses or horizontal layers, instead of the one course usually put down in this country, in the case of single storey buildings. The stones should be roughly squared with a stone-hammer or, as it is called, "hammer dressed."

The lower of these courses should be laid on a bed of lime mortar, spread on the bottom of the foundation trench to a thickness sufficient to insure that each stone is solidly bedded in it. Spaces which occur between the bottom of the trench and the under faces of the stones, due to the latter not being quite flat, should be filled with single chips hammered solid into place. The stones ought to be laid on their "natural bed," i.e. with the laminations, or thin layers of which the stone is composed, in a horizontal position. The largest stones should be used for this lower course. As in all stone-work, stones with cracks in them should not be used. The mortar joints should not exceed $\frac{3}{4}$ inch in thickness, and should be completely filled with mortar.

The second course should be built so that the stones composing it "break joint" with the lower course, i.e. the mortar joints in the

upper course should be as far removed as possible from occupying positions vertically above the joints in the lower course. This is fully explained in the discussion on "bond" contained in the next chapter. As there mentioned, frequent "headers" should be inserted. The preceding remarks apply to succeeding courses, in the event of the footings being deep.

Trenches which are to receive stone or brick footings should be excavated wide enough to leave at least a 4-inch space on each side of the footing, in order to allow working room for the builder. For concrete footings, however, the trenches should be excavated to the exact width required, and entirely filled with concrete. Spaces left between brick or stone footings and the sides of the foundation trenches, should be rammed in with earth after the footings have been completed, care being exercised not to weaken the footings by too violent ramming.

The footing should extend to a height of at least 9 inches above the ground surface, at the highest point of the latter. The upper surface of the footing should be finished flat and level to receive the damp course.

Damp Course.—The function of the damp course is to prevent damp from rising into the walls above ground.

It usually consists of asphaltic or bituminous felt, which can be purchased from suppliers of building material, under the name of "damp-course felt." The upper surface of the footing should be covered by a continuous layer of the felt, any junctions between different lengths of felt being formed by overlapping the two lengths to an extent of at least 6 inches.

Another form of damp course is one which may be applied in a semi-liquid state. It is prepared by boiling tar, and adding sand till the mixture assumes the consistency of thick porridge. The addition of a little pitch is advantageous, as it causes the mixture to solidify better, thus making it less liable to be squeezed out by the weight of the wall on top of it. The mixture should be applied hot to the top of the footings, with the aid of a trowel, to a thickness of $\frac{1}{4}$ to $\frac{3}{8}$ inch. About two days after its application this type of damp course will be solid enough to allow of the walls above it being commenced.

Examples of masonry footings are shown in many of the illustrations in this book. It will be noticed that the outer top edge of the footing is bevelled off, or "weathered" as it is called, so as to shed rain-water.

CHAPTER IV

BOND—BRICKWORK—HOLLOW BRICK WALLS—STONEWORK

Bond.—Brick, and also stone walls are built with due regard to the proper bonding or interlocking of the component bricks or stones, in order to form a strong and stable structure. The word “bond” is used to denote the laying of bricks or stones so as to avoid the occurrence of continuous vertical joints. Bond is much more definite in brickwork than in stonework, hence the former will be described first, and the principles enunciated can be considered to apply, in a modified degree, to stonework.

Brickwork.—All walls settle, or subside, somewhat, after having been built, due to the compression of the mortar while it is still comparatively soft. If this settlement occurs irregularly, *i.e.* if one part of the wall settles more than, or at a different time from, adjoining parts, cracks known as “settlement cracks” are formed. In order to insure more or less regular and contemporaneous settlement, and thus avoidance of the above evil, three points require attention, they are:—

1. The mortar joints should be thin, not exceeding $\frac{3}{8}$ inch in thickness in the case of brickwork.
2. Horizontal joints should be of uniform thickness.
3. In building the wall be careful not to advance any one part in height much beyond adjoining parts, but raise the wall more or less uniformly along its whole length.

All joints should be completely filled with mortar. In order to effect this, especially in the case of the joints in the middle of the thickness of a thick wall, *grouting* is commonly resorted to. By “grouting” is meant the pouring of mortar, thinned with water, into the joints in question.

Each brick is thoroughly wetted immediately before being laid, to prevent too rapid drying of the mortar, and to remove any dust, from the surface of the brick, which would prevent proper adherence of the mortar.

The usual method adopted in brick-laying is first to build up the bricks at the corners of the building, say to a height of 6 or 7 courses, a mason's plumb-rule being used as shown in Fig. 12 to keep the corners truly vertical. For this purpose a plumb-rule is much to be preferred to a spirit-level. The brickwork between these corners can now be quickly laid, by stretching a line from corner to corner, and using it as a guide to keep the face of the wall true. In this way the plumb-rule need only be used on the corners of the building, and the remainder is constructed by the much easier method of building to the line. Having built up the part between, the corners are again advanced, and the process is repeated.

FIG. 12.

As has already been mentioned when speaking of "settlement," the walls should be raised regularly so that at any one time no part is higher than 4 feet above an adjoining part. Otherwise, when the adjoining part is raised, the amount which it has to settle will probably exceed the amount of residual settlement still to be performed by the older part of the wall, by an extent sufficient to give rise to a crack between older and newer parts of the wall.

Should one part of a wall be unavoidably delayed, the part carried on should be "racked" back in a series of steps, at the end where the new part is to join it, so as to obviate the aforementioned ill effects (see Fig. 12).

TERMS USED IN BRICKWORK

Stretcher.—A brick laid with its length parallel to the length of the wall, of which it forms a unit, is called a *stretcher*.

Header.—A brick laid with its length across, or at right angles to, the length of the wall, is termed a *header*.

A Stretching Course is a course, or horizontal layer of bricks, composed entirely of stretchers.

A Heading Course is a course consisting of headers only.

Queen Closer.—A brick halved longitudinally forms two queen closers. As this is difficult to do satisfactorily, the brick is generally first cut in halves transversely. From one brick, we thus get four half-queen-closers. Closers are used to break the continuity of vertical joints, thus producing bond.

Bats are portions of bricks. A brick halved transversely gives two half bats. If one quarter of the length of a brick be cut away, the remainder is a three-quarter bat.

Thickness of Brick Walls.—This is customarily stated either in inches or number of bricks. Thus a half-brick wall is "half-a-brick" or $4\frac{1}{2}$ inches thick; a one-brick wall is one brick or 9 inches thick; a one-and-a-half brick wall is $1\frac{1}{2}$ bricks plus a mortar joint, or 14 inches thick, and so on.

DISTINCTIVE BONDS

Different bonds are in use. The ones of most importance in farm buildings are Stretching, Heading, English, and English garden or Colonial bonds. Flemish bond may also be mentioned.

Stretching Bond.—In stretching bond all the bricks, which compose the wall, are laid as stretchers. This bond is used for $\frac{1}{2}$ -brick walls (see Fig. 22).

Heading Bond.—In heading bond all the bricks are laid as headers. This bond is commonly used for turning sharp curves, since the short ends of the headers conform better to the curve of the wall than would the long edges of stretchers. An example of heading bond as used in the construction of a circular sheep-dipping tank is illustrated by Fig. 191.

English Bond.—In English bond the bricks are laid so that they

appear, on each face of the wall, as alternate courses of headers and stretchers. It is the strongest bond, though it may not look so neat as some of the others.

Fig. 13 shows a one-brick wall built in English bond. It will be noticed that the second course from the top is shown again, moved to the right, so as to illustrate the arrangement of the bricks composing it. This is done also in succeeding illustrations. Referring to Fig. 13 it will

FIG. 13.

be observed that alternate courses consist entirely of headers and stretchers respectively. The vertical joints in the header courses are prevented from coming in line with those in the stretcher courses, by the insertion, in each header course, of two half-queen-closers between the end full-brick and the next one. This method of neatly finishing off the end of a wall is known as *return bond*. Return bond is employed, also, for the jambs, or vertical edges, of openings for doors and windows.

Fig. 14 illustrates a $1\frac{1}{2}$ brick wall in English bond. The method of finishing off alternate courses at the end of the wall, or at a jamb,

FIG. 14.

will be seen from the drawings of the top course and the next lower course in the figure. Thus the top course is finished off by three stretchers, and the next lower course by two three-quarter bats and three half-queen-closers.

Angles or Quoins in English Bond.—The method of laying the bricks at right-angled corners, or *quoins*, formed by the junction of two walls, is illustrated by Figs. 15 and 16.

Fig. 15 shows a quoin made by the junction of two 9-inch walls. The bond is clearly shown in the figure, which requires little explanation. It will be seen that the continuity of vertical joints is broken by the

insertion of queen closers, in the heel of the L, in each of the two meeting walls alternately.

FIG. 15.

FIG. 16.

FIG. 17.

FIG. 18.

Fig. 16 illustrates a quoin made by the junction of two 14-inch walls. Figs. 17 and 18 illustrate both return bond and quoins for two-brick,

and two-and-a-half brick walls respectively. In each case plans of alternate courses are given. Walls of these thicknesses are required in the construction of brick silos, which have to stand a severe bursting stress due to the pressure exerted by the ensilage within them.

Junction between Main Walls and Party, or Cross Walls, in English Bond.—Fig. 19 shows the bond between a 9-inch main wall and a 9-inch

FIG. 19.

FIG. 20.

party wall. Bond between the two walls is obtained, in alternate courses, by the insertion of queen-closers at AA.

Fig. 20 illustrates the bond between a 14-inch main wall and a 9-inch party wall. In this case bond between the two walls is obtained by the insertion of $\frac{3}{4}$ bats BB in alternate courses.

Fig. 21 shows the bond between 14-inch main and party walls.

The junction of a $4\frac{1}{2}$ -inch party wall with a 9-inch main wall is illustrated by Fig. 22.

FIG. 21.

English Garden, or Colonial Bond.—This bond, a modified form of English bond, contains fewer headers than the latter.

In English garden bond the bricks are so laid that, on looking at either face of the wall, the bricks of only one course out of every four or five appear as headers, the bricks of the other courses appearing as stretchers.

In each of the figures illustrating English garden bond four courses are shown, separated vertically for the sake of clearness.

Figs. 23 and 24 illustrate English garden bond in the cases of 9-inch and

FIG. 22.

FIG. 23.

14-inch walls respectively, and also show how jambs would be formed.

Fig. 25 shows a quoin formed by the junction of two 14-inch walls.

FIG. 24.

FIG. 25.

Fig. 26 illustrates the junction between a 9-inch party wall and a 14-inch main wall.

Advantages of English Garden Bond.—If we look at the face of a wall built in English bond we notice that the overlap of bricks in any one course, beyond bricks in the courses immediately above or below that one, amounts to $\frac{1}{4}$ brick or $2\frac{1}{4}$ inches.

Now examine the figures illustrating English garden or Colonial bond, and it will be seen that only half of the courses overlap by $\frac{1}{4}$ brick, the remainder overlapping by $\frac{1}{2}$ brick or $4\frac{1}{2}$ inches. This is claimed as an advantage, since farm buildings are often erected by labour not fully

FIG. 26.

skilled, and, in the case of Colonial bond, there is more overlap to come and go upon (in at least half the courses) than is the case in English bond. This lessens weakening of the wall due to inaccurate placing of the bricks in a horizontal direction. For instance, if a brick in English bond be out of place to the extent of 1 inch horizontally, the overlap is reduced to only $1\frac{1}{4}$ inches, but in Colonial bond—in the case of at least 50 per cent. of the courses—the overlap would still be as much as $3\frac{1}{2}$ inches.

In the case of the employment of a semi-skilled man, however, this fact does not justify the acceptance of poorer work than he is capable of; nor does it excuse any relaxation in the closeness of the supervision exercised by the farmer, or person in charge of the work.

While Colonial bond is weaker than English bond, it is quite satisfactory for one-storey buildings, though this does not imply that it should be used in all cases in preference to English bond, which is the stronger when properly laid. For two-storey buildings, and even for one-storey buildings which have to carry a heavy roof, English bond should be used, as the Colonial bond has not a great enough weight-carrying capacity. Walls which are called upon to support shafting should preferably be built in English bond.

For 9-inch walls both faces of which are unplastered Colonial bond is employed, hence probably the origin of the name "garden" or "garden wall" bond. The object in view is to reduce the number of headers, a fair or plane face on each side of the wall being then easier of attainment, because the transverse position of stretchers can be adjusted so as to keep the two faces plane, but longer headers must project beyond shorter ones, there being always some variation in the lengths of ordinary bricks.

A modified type of garden bond is shown in the division walls between the exercise yards in Fig. 147. In this case there are three stretchers to one header, in *each* course.

Flemish Bond.—Flemish bond is illustrated by Fig. 27, which shows a 9-inch wall built in this bond. It will be seen that, unlike English bond in the case of a wall of this thickness, headers and stretchers occur in *each* course.

This bond is supposed to lend an effective appearance to the fronts of cottages, especially when the mortar joints are lined in with white paint. It is not so strong as English bond.

FIG. 27.

Hoop Iron Bond (Fig. 28).—Hoop iron is frequently used for the purpose of strengthening brick walls. The hoop iron is well tarred and sanded and is then built into the wall at vertical intervals of 5 feet or thereabouts. As a rule one strip of hoop iron is inserted for every half-brick the wall is in thickness. Wherever possible, as for instance above

door and window openings, continuous strips, extending right round the building, should be built in. In other cases the strips of hoop iron inserted should be as long as the positions of openings in the wall will allow of. Joins in the hoop iron at quoins, and between separate lengths,

FIG. 28.

may be made by bending over the ends, and hooking one length on to the next.

Broken Bond.—The brick-layer sets out the bond, relatively to door and window openings, etc., right from the lowest course. On referring to Fig. 37 it will be noticed that the right-hand ends of the stretchers X, X, X are kept in line vertically with the left-hand jamb of the window opening. Similarly the left-hand ends of the stretchers Y, Y, Y are set in line vertically with the right-hand jamb. In most cases closers such as Z, Z, Z will require to be inserted, as shown, below the middle of the window-sill.

Figs. 29 and 30 illustrate the use of closers in a pier between two jambs (either door or window jambs), the closers being marked A, B, and Z respectively. The figures are self-explanatory, the topmost course being supposed lifted in order to show the course below.

There is a good deal to be said in favour of the practice of designing brick buildings to “brick-dimensions,” so as to minimise the use of closers. This means that horizontal dimensions, when expressed in inches, should be divisible by $4\frac{1}{2}$; and vertical dimensions, expressed in inches, by 3.

Hollow Brick-walls.—Hollow, or cavity walls are employed with two purposes in view:—

1. To exclude the damp, and,
2. To keep the interior of a building at a more uniform temperature than is possible with solid walls of equivalent thickness.

In some instances, for example in the case of dairies, the second purpose is the more important, hollow walls being employed chiefly in order to keep the interior of the building in question as cool as possible in summer.

Hollow walls consist of two separate vertical portions standing parallel to each other, and separated by an air-space or cavity, which varies in width from 2 inches to $4\frac{1}{2}$ inches in different walls. The layer of air contained in the cavity is a bad conductor of heat, which phenomenon results in a building that has been provided with hollow

FIG. 29.

FIG. 30.

walls being cooler in summer (and by day) and warmer in winter (and by night) than it would be if it had solid walls of equivalent thickness of brickwork.

The air space in the wall should have no communication with the outer air, it is therefore shut off from the latter by a covering course of brickwork at the top of the wall.

As a rule, one of the portions forming a hollow wall is built $4\frac{1}{2}$ inches thick. The other portion, separated from the first by the air-space, may be 9 inches or 14 inches thick, according to the strength required.

The two portions are bonded or tied together. Various types of ties

are used. In Fig. 31 three different types are illustrated. The two ties on the left are made of wrought iron, about $1\frac{1}{4}$ " by $\frac{1}{8}$ " in cross section. The ends of these ties are split, and splayed out, so as to give them a good hold in the mortar. One of the ties shown is twisted, while the other is bent down, at mid-length, in order to throw off any moisture coming from the outer portion before it reaches the inner portion of the

FIG. 31.

wall. The third tie illustrated (on the right) consists simply of a piece of wire—several strands twisted together—bent so as to gain a grip in the mortar. Such ties may conveniently be made from twisted wire droppers for fences. All the above ties should be dipped, while hot, in tar, before being built into the wall.

An objection to wrought-iron ties is that they are subject to rust, which may cause them to expand, and so injure the wall.

Pieces of slate slab, or of dense non-porous stone, are also used as ties, but are apt to break should the two portions of the wall settle unequally.

Ties, spaced about two feet apart horizontally, may be inserted every third course of brick-work. The ties forming any one horizontal row should be situated over the middles of the spaces between the ties of the horizontal row next below.

Sometimes the thinner portion of a hollow wall is built on the outside, sometimes the thicker. The former method is probably the better, since only the thinner portion can become wet, and also because the two wall-plates (which are built into the thicker portion of the wall) are closer together, resulting in a smaller effective roof span and therefore a lighter roof.

It is a good plan to commence the cavity below the level of the damp course. The latter will then be above any water which may accumulate at the bottom of the cavity (see Fig. 31). Very hard bricks, built in cement mortar, should be used below the damp course, and these bricks should be rendered or plastered with cement mortar on their surfaces next the cavity.

When the $4\frac{1}{2}$ -inch portion of a hollow wall is on the outer, or weather side it should be rendered with good plaster to a thickness of about $\frac{3}{4}$ inch, and the plaster should be painted with a good water paint.

The dairy illustrated on pages 174-5 is provided with hollow walls.

Stonework.—Building in stone calls for more skill than does building in brick, because the mason receives the stones in irregular shapes and sizes. Due attention should be paid to the provision of proper bond, which is much more difficult to arrange for than when bricks are used, and which therefore cannot be expected to be so perfect as in brickwork.

In the case of stratified rocks, such as sandstone or limestone, the stones should be laid on their *natural bed*, i.e. with the layers, or *laminæ*, of which the stone is built up, in a horizontal position. Stones without a definite stratified structure such as dolerite (also called iron-stone or *ijzer klip*) may of course be laid in any convenient position.

Stone walls are built in a manner similar to that already described for brick walls, the corners or quoins being raised first to a height of about 3 feet, the plumb-rule being used to keep them truly vertical. The space between the quoins is then built up, a line stretched from quoin to quoin serving as a guide.

The best stones should be selected for quoins, jambs, lintels, sills, etc. Such stones are usually dressed with extra care, the stone-chisel being sometimes used as well as the hammer. Corner stones should be laid with their lengths alternately along each of the two walls, so as to bond properly into each wall (see Fig. 32).

If a wall be more than one stone thick, it must be bonded transversely as well as longitudinally. This is done by the insertion of *through stones*, or of *bond stones*, which correspond to headers in the case of brickwork. These stones lie across the wall, *i.e.* at right-angles to its length.

FIG. 32.

A through stone reaches clear through the thickness of the wall from front to back face, bond stones only far enough, from $\frac{2}{3}$ to $\frac{3}{4}$ the thickness of the wall, to sufficiently overlap similar bond stones reaching from the other face (see Fig. 33). This latter arrangement receives the name of "cross bond," and is to be preferred in external walls, if they are thick enough, because through stones are liable to conduct dampness to the interior of the building, and also because, especially in rough walling, through stones are liable to snap across due to unequal settlement in the wall. Should this occur to a through stone, it can no longer perform its office of bonding the front and the back of the wall together, and the latter is seriously weakened.

From $\frac{1}{6}$ to $\frac{1}{8}$ of the face area of a wall should be bond stones. They should be inserted in every course, and the bond stones in any one course should lie over the middles of the intervals between bond stones in the course immediately below.

Classes of Masonry.—There are two chief classes of masonry, viz.:—*rubble* and *ashlar*. In rubble masonry the stones are only roughly hewn into shape, while ashlar consists of stones carefully squared and dressed so as to insure thin mortar joints. Rubble masonry is of more interest to the farmer than ashlar. In farm work two sub-classes are employed, viz.:—*rough rubble* and *squared rubble*.

Rough rubble.—This type of rubble is also termed “common” or “random” rubble. It is illustrated by Fig. 33. The stones are of all

FIG. 33.

shapes and sizes, only the most awkward corners and projections being chipped off with a hammer. Considerable skill and great care are required in fitting the inequalities of the stones into each other, in order to procure good bond. In general a few of the larger stones should be arranged first, as bond stones and to break joint. These are then packed up below, where necessary, by the insertion of stone chips or “spalls.” The intervals between these stones are then filled with smaller stones and spalls, and the whole thoroughly flushed up with mortar. These processes are repeated as the wall rises, care being exercised to avoid long vertical joints, not only on the faces, but also in the interior, of the wall. No wedge-shaped stone or spall should be laid point downwards, especially in the interior of the work. If so laid it will act as a wedge, when

pressure comes upon it, and tend to burst the masonry apart. The compressive strength of rough rubble scarcely exceeds that of the mortar used, but wherever possible stone, even though in the form of spalls, should be used in preference to mortar, so as to preserve the strength and prevent excessive settlement.

Squared Rubble, or Snecked Rubble (see Fig. 32).—The stones for masonry of this class are roughly squared by means of a stone-hammer, to show horizontal and vertical joints when built into the wall. Stones squared in this way are said to be hammer-dressed. As shown in the illustration the dressing of the stones to form vertical joints is confined to the first two or three inches back from the face, the tails of the stones being left rough.

Block-stone Masonry.—If the stones be squared *all over* with the hammer, and neatly fitted together without the insertion of spalls, so as to give vertical and horizontal joints in the interior, as well as on the faces, of the wall, the work is called “block-stone masonry.” This class of masonry may be looked upon as lying between rubble and ashlar.

CHAPTER V

OPENINGS IN WALLS—ARCHES, LINTELS—WINDOW SILLS—CORBELLING—
OFF-SETS—COPINGS—ATTACHMENT OF WOODWORK TO BRICKWORK
AND MASONRY—FIREPLACES—CHIMNEY SHAFTS AND FLUES

Openings in Walls for Windows, Doors, etc.—The jambs of these openings are finished in return bond as already explained. Openings in walls may be bridged either by an arch or a lintel. The terms used in connection with arches are illustrated by Fig. 34, and are as mentioned in the following paragraph.

The *arch ring* is built up of *voussoirs*, V. The voussoir K is called the *key stone*. The ends of the arch ring rest on *skew-backs*, which are the sloping surfaces *Sk*, *Sk*, formed on the *abutments* AA. The lower surface (concave downwards) of the arch ring is called the *intrados* or *soffit*, I. The lines in which the intrados intersects the *jambs*, JJ, are called the *springings*, *Sp*, *Sp*. The outer surface (convex upwards) of the arch ring is called the *extrados* or *back*, E. The highest portion of the extrados is the *crown*, Cr, and the lower portions from *A*₂ to *B*₂, and from *A*₁ to *B*₁, are the *haunches*. R is the *rise* of the arch, and C the *centre*. The masonry, SS, between the extrados and the broken lines, forms the *sandrils*.

FIG. 34.

Brick Arches.—In farm work, brick arches are generally built of uncut bricks; that is to say, the bricks are not chipped, or cut with an axe, or rubbed to the required wedge-shape. This wedge-shape, either of the voussoirs or of the mortar joints between them, is an essential feature of the arch. When uncut bricks are used, it is the mortar joints (as will

be seen from the accompanying illustrations) which are wedge-shaped.

Arches should be built of carefully selected bricks, laid in cement mortar consisting of 1 part cement to 3 parts clean, coarse sand. The bricks should be soaked just before they are laid, in order to prevent rapid absorption of water from the mortar and consequent weakening thereof. The rise of an arch for an opening 3 feet wide may be about 3 inches, and proportionately larger for wider openings.

Fig. 35 illustrates an *outside* door frame, the opening for which is bridged by an arch consisting of two half-brick rings. These are used

FIG. 35.

in preference to one full-brick ring 9 inches thick, since the thickness of the mortar joints, at the convex surface of each half-brick ring, will be much less than that of the joints at the corresponding surface (extrados) of the equivalent full-brick ring. In positions where great weight is to be borne, as in a two-storey building, three half-brick rings would be used. The space between the head of the door frame and the intrados

is built in with pieces of brick, this filling being called the *core*.

FIG. 36.

While an arch is in process of being built, a temporary support usually of timber, known as a *centering*, must be used. Such a centering is shown in Fig. 36. It is supported by planks P,P, the

lower ends of which rest on any convenient solid surface, such as a

window sill in the case of a window opening. These planks should be carefully placed and, if necessary, wedged up, in order to support the centering as solidly as possible.

In the case of the door opening (Fig. 35) the centering would be placed in position behind the door-frame. The core would then be built on top of the door-frame, the centering being used as a guide in building it. Next, the arch ring would be built on top of the continuous surface formed by the core and the centering.

While building in window frames (see Fig. 37) for stables, byres, etc., two half-centerings would require to be used, one being fixed in front

FIG. 37.

of the window frame and one behind. In the case, however, of dwelling houses (and sometimes in that of stables, byres, etc.), the inside centering is unnecessary, its place being taken by a permanent $4\frac{1}{2}$ " by 3" lintel—set with the greater dimension horizontal—upon which the core and arch are built. Note from Fig. 37 how the bricks forming the lower arch ring are cut away slightly as they approach the jambs, so as to allow the window frame to penetrate the arch ring to an extent of about $1\frac{1}{2}$ inches at each springing. The bricks forming the jambs are also cut away, as at A and B, to allow the window frame to penetrate each jamb to a depth of about 1 inch.

The arch shown in Fig. 38 for an *inside* door requires no centering, being built on top of the core (not shown) which, in turn, is carried by

FIG. 38.

the two $4\frac{1}{2}$ " by 3" wooden lintels. This arch is intended to relieve the lintels of some of the stress, and is therefore called a *relieving arch*.

An arch over a fire-place is generally supported by an iron bar (or bars) curved to fit the soffit of the arch, and called a *turning bar*. See

FIG. 39.

Figs. 39, 46, and 47. Turning bars may be made of old tyre iron. A turning bar should have a bearing on each jamb of $4\frac{1}{2}$ inches, and its ends should be turned

up, or down, for about 3 inches, so as to enter the vertical joints between the bricks. A turning bar (or bars) serves as a centering on which to build the arch, as well as strengthening it when built. The

arch should, of course, be built in cement mortar. Turning bars are often used for arches above doors and windows in farm buildings.

If centering be used it should be left in position for at least one week after the arch, which it supports, has been finished.

Lintels.—While these are sometimes of stone, reinforced concrete is rapidly displacing that material. Reinforced concrete lintels are often used in preference to brick arches. They should be 18 inches longer than the width of the opening which they span, thus having a bearing, at each end, of 9 inches on the brickwork of the jambs.

Concrete lintels are moulded in position, the mould being formed of boards. A suitable concrete consists of 1 part cement, to 1 part clean

FIG. 40.

sand, to 3 parts broken stone. As in all reinforced concrete work, the stone should be broken small, say to pass a $\frac{3}{4}$ -inch ring, so that it will pack closely around the reinforcement.

Fig. 40 shows a lintel reinforced with two fencing standards. These, as will be seen from the illustration, are placed near the lower face of the lintel, where they are most effective.

The following specifications are laid down by the Public Works Department of the Union of South Africa :—

“Over openings with straight heads cast cement concrete lintels the full thickness of walls, 18 inches longer than the width of the openings, and of the following depths :—

Clear span not exceeding—	Depth of lintel.
3' 6"	Three courses of brickwork.
4' 0"	Four courses of brickwork.
4' 6"	Four courses, with heavy section fencing standards, weighing 3 lbs. per foot, built one into each 9 inches of width of soffit, or part of 9 inches.
5' 6"	Four courses, with <i>two</i> rows of fencing standards spaced as above.

For openings exceeding 5' 6" in width use 4" by 1 $\frac{3}{4}$ " by 5 lbs. per foot rolled steel joists, say one for spans of from 6 to 8 feet, and two for spans exceeding 8 feet."

The above specification does not call for reinforcement of lintels

FIG. 41.

the span of which is less than 4 feet. As, however, partially skilled labour is often employed on farm buildings, it might be well to reinforce all lintels the span of which exceeds 3' 6".

Window Sills.—Window sills are generally of brick, Fig. 37, or of concrete, Fig. 41.

If a window be at all exposed to the weather a *water-bar* is fitted, consisting of an iron bar embedded half in the wooden sill of the window frame and half in the concrete or brick sill. Concrete sills are moulded in place; brick sills are built in cement mortar.

Referring to Fig. 41 the use of a *throat*, or groove, in both wooden and concrete sills will be noted. A throat throws off rain-water, which would otherwise find its way along the under surface of a sill. A similar groove is formed in the plaster with which a brick sill is rendered.

The top of a window sill should be sloped, or *weathered* as it is called, from A to B (Fig. 41), so as to throw off the rain-water. Note how the slope is carried back for about $1\frac{1}{4}$ inches below the wooden sill. This, in conjunction with the throat T, tends to prevent the penetration of water into the joint between the wooden and the concrete (or brick) sills.

The window shown in Fig. 41 is provided with a window-board, lining, and architrave, as marked on the figure. These, of course, would be omitted in the case of stable buildings, etc.

If a sill consists of one stone which, as is usually the case, is built in during the progress of the brickwork, it should bear on the brickwork for about 3 inches of its length at each end only, a space of about $\frac{3}{8}$ inch being left below the intermediate portion. The reason for this is that, on account of the superior weight of the jambs, the settlement of the brickwork under each end of the sill is greater than that of the brickwork under the middle of the sill. Consequently, if the sill bore hard on the brickwork below the middle of its length, it would be bent convex upwards as settlement proceeded, and would probably fracture at or about mid-length.

The same precaution should be observed in the case of concrete sills. A board should be placed below the space which the sill is to occupy. This board should be slightly wedged up upon the brickwork, and should extend to within 3 inches of each end of the sill. The sill is moulded on top of the board, and as soon as the concrete has set sufficiently the board should be removed. Its removal is easily effected by first removing the small wedges underneath it. In this way a space is left between sill and brickwork, all along the length of the former with the exception of 3 inches at each end. When the building has reached the pointing stage, this space may be filled up with safety.

Brick Corbelling.—(See Fig. 42.)

Corbelling is an artifice employed to form a ledge to carry a wall-plate, the ends of joists, etc. The amount of projection of each course of brickwork, beyond the one immediately below it, should be less, the greater the weight to be borne. In the figure it is $1\frac{1}{8}$ inches. It should on no occasion exceed 2 inches.

Off-sets.—(See Fig. 43.)

An offset is a ledge formed in a wall by suddenly reducing its thickness, as for instance in passing from a lower to an upper storey. On the ledge a wall-plate may be supported. An offset is frequently used to support the plates for ground floors.

Copings.—A wall which is unprotected by a roof, as for instance a yard wall, should be provided with a coping to prevent rain from

FIG. 42.

FIG. 43.

FIG. 44.

FIG. 44A.

percolating into the body of the wall. Sometimes the coping is made to project beyond the face of the wall on each side, but this should never be the case in yards where cattle are to be confined, on account of the danger of the animals' horns breaking off lengths of the coping.

A coping, finished in cement mortar, is shown in Fig. 44. Here a line of stretchers, S, is laid along the middle of the top of the wall, the corners being filled in with brick chips C, and the whole plastered over with one to three cement mortar, and finished off smoothly to a semi-circular section.

Specially impermeable, purpose-made bricks are occasionally obtainable for copings. They should be laid in cement mortar. A form suitable for farm purposes is illustrated by Fig. 44A, in cross-section,

Joint for Farm Buildings.—Fig. 45 shows how the mortar joints between bricks are commonly finished off in farm buildings. This type of finish is called a *struck* or *weather* joint.

The Attachment of Timber to Brickwork.—For this purpose, one method employed is to build wooden blocks, of a thickness equal to that of a brick plus two mortar joints, into the brickwork wherever required to receive the nails. These blocks, however, are large, and the shrinkage in them is correspondingly great, hence they frequently become loose.

FIG. 45.

It is better practice to build thin slips of wood, about $\frac{3}{8}$ inch thick, into the joints between the bricks where required, as the wall is being built. These slips should be placed so that the nails are driven into them across the grain, *i.e.* not into "end-wood." They are often cut from ceiling boards. To these slips, woodwork, such as skirting-boards, linings, architraves, etc., are nailed.

When timber is to be fixed to a wall already built, wooden plugs about 5 inches long are usually driven into the mortar joints between the bricks or stones, to receive the nails. This, however, on account of the wedging action involved, is apt to shake or displace the bricks or stones, and the structure may be seriously weakened. A better plan, though one involving more labour, is to drive the wooden plugs into holes made in the brick or stone itself.

It need hardly be mentioned that wooden plugs should never be placed in walls near flues or fire-places.

Chimneys and Fire-places.—Since, as a rule, fire-places require more depth than can be provided in the thickness of the wall, a projection to contain fire-place and flue is necessary. This projection is called a *breast*; it may contain more than one flue.

In most cases the breast is built on the inner side of the wall, but sometimes on the outside. With the latter arrangement more space is available in the room, and the apartment also has a better shape. In the piggery illustrated in Fig. 155 the breast is shown on the outer side of the wall.

Fire-places (see Figs. 46, 47 and 214).—A fire-place 3' 6" wide is large enough for a range, while for an open grate, such as is used in sitting rooms, 2' 6" is a sufficient width.

The fire-place should be so formed that the air is caused to pass

either through, or at least very near to, the fire. The reason for this is that the draught is due to hot air, which ascends the flue on account of its being lighter than cold air. Thus a high opening above the fire is bad, because it allows an excess of cold air into the flue and, in this way, spoils the draught. The arch bridging the fire-place should therefore be situated not far above the grate.

This arch should be built upon, and strengthened by, a turning bar (or bars) as already mentioned in the section devoted to arches (page 44).

Flues (see Figs. 46, 47, 214, and 214B).—Each fire-place should have a distinct and separate flue to itself. If the flues of two different fire-places

FIG. 46.

FIG. 47.

communicate, then when one fire only is lit, air coming from the flue of the other will interfere with the draught. Further, smoke from the active flue may find its way down the other flue, and enter the apartment from which the latter leads, causing what is known as "back smoke." If the partition or *withe* between two adjacent flues be badly built, communication between them may be established, thus giving rise to the above evils.

Flues should not be built bigger than the size necessary to carry off the smoke. If a flue be made too big the draught is unsatisfactory, and it is easier for gusts of cold air to stream down the flue, so causing the fire to smoke. Generally speaking a flue 7 or 8 inches square is sufficient to carry off the smoke from small grates or stoves, while a flue 9 or 10 inches square will do for large kitchen ranges. The ordinary flue in single-storey cottages is made 7 or 8 inches square.

It is advisable to build flues with a curve in them, to prevent rain from beating down on to the fire, and also to stop down-draughts of cold air. The deflection of the flue, due to this curve, should be great enough to prevent a person, looking up the flue, from seeing day-light. The curve should be gradual; no flue should contain sharp turns or angles, because these would interfere with the draught.

Immediately above the fire-place the brickwork is gathered over,

by corbelling, so as to produce a gradually diminishing passage from the dimensions of the fire-place down to those of the flue. The centre of the flue, immediately above this diminishing part, should be vertically above the centre of the fire-place.

Chimney Shaft.—When the breast reaches the ceiling of the highest room, it is reduced in cross-sectional dimensions until it is only wide enough to contain the flues. This reduced part is known as the chimney-shaft. Where the chimney-shaft passes through the roof-covering, it will require to be “flashed” (see Chap. VI., p. 64, Figs. 65 and 66).

Chimney-pots or Cans.—Chimney-pots of earthenware are often placed over flues to prevent the formation of wind eddies, which would be caused by the flat surface of the top of the chimney shaft. The top of the chimney cans should not be lower than the highest part of the building, in order to prevent down-draughts.

Precautions against Fire.—No wooden plugs or slips should be built into walls near flues. It should also be remembered that iron brackets or spikes, driven into the walls of breasts, may conduct sufficient heat to the woodwork which they support, to ignite it.

A suitable method of supporting a mantel-piece is shown in Fig. 214. Any nails, or supporting spikes, are driven into the thick brickwork below the mantel-piece, care being taken that no metal comes near to the interior of the flue.

Building the Flues, etc.—Chimney breasts, even in stone buildings, are generally built of good hard bricks in preference to stone, which is a difficult material to work with for this purpose, and is generally less satisfactory than brick. In the case of a stone building, however, that part of the chimney shaft which is above the roof covering may be built of stone for the sake of appearance.

The external walls of chimney breasts should be 9 inches thick, rather than $4\frac{1}{2}$ inches. The provision of 9-inch external walls within the building reduces the risk of woodwork near the breast becoming ignited. It is also advantageous to have a 9-inch wall round the chimney shaft, because that part which is above the roof-covering is exposed to the weather, and a $4\frac{1}{2}$ -inch wall is apt to be breached, in which event cold air is admitted to the flue causing it to smoke.

Notwithstanding the above disadvantages the external walls of both breast and chimney shaft are, in ordinary buildings, usually made only $4\frac{1}{2}$ inches thick, for the sake of economy. In this case, the part above

the roof-covering should be either built in cement mortar, or plastered with cement mortar, to enable it to resist the weather.

The bond will be much broken, but general principles should be kept in view while the chimney is being built.

Rendering.—Sometimes, but rarely in South Africa, the inside of flues is rendered with 1 to 3 cement mortar.

Pargetting or Parging.—The more common procedure, in this country, is to plaster the inside of the flues with 1 part lime to 3 parts cow-dung, or with 1 part good clay to 3 parts cow-dung. This forms a lining which is smooth, tough, and not easily cracked.

Coring, etc.—As a flue, in process of being built, rises, it should be kept plugged a little below building-level by a bundle of rags or shavings called a "sweep." This prevents mortar from falling down, and adhering to the sides of, the flue.

After a flue is finished it is advisable to pass a wire-brush, or "core," through it to clear away any small obstructions.

Round Flues.—A round flue is theoretically the most perfect, but is difficult to build. Earthenware pipes, jointed with 1 to 2 cement mortar and surrounded by brickwork, are sometimes used.

CHAPTER VI

ROOFS, AND ROOFING DETAILS

THE carpenter understands by the word "roof," the timber frame-work which supports the covering of a building. The covering itself may be spoken of as the "roof-covering."

Roof-coverings are carried, in the first instance, by a series of frames called *principals* or *roof trusses*, which span across the building to be roofed.

In South Africa roofs are seldom, indeed in the majority of cases never, called upon to bear heavy snow loads. Further, corrugated galvanised iron is in general use as a roof-covering, and this covering is much lighter than the slates or tiles commonly employed in Europe. For these two reasons roofs in South Africa do not require to be so strong as those in Europe. It should, however, be remembered that roofs with less than a certain slope may fail to shed hail as it falls. This concerns not only the strength of the roof, but also its freedom, or otherwise, from leakage.

Principals of roofs in South Africa, unless of exceptional span, are commonly constructed of planks $1\frac{1}{2}$ inches thick, simply nailed or bolted together. This does away with the necessity for the elaborate mortise joints found in the stronger European roofs built of timbers of heavy cross-section; hence "plank-roofs" are eminently suitable for farm buildings where skill to construct the above-mentioned mortise joints may be lacking.

These plank principals are spaced about 5 feet apart, and carry 2" by 3" timbers called *purlins* to which the roof-covering of corrugated galvanised iron is nailed. The purlins run parallel to the length of the building.

Pitch of Roofs.—The term "pitch" applied to a roof means the

amount of slope given to the roof-covering. It may be measured in two ways:—

1. by the angle (a , Fig. 64) which the roof-covering makes with the horizontal,
2. by the proportion which the rise of the roof bears to the span, or distance bridged.

The following table shows the connection between these two methods of stating the pitch of a roof.

The rise expressed as a fraction of the span.	Angle of inclination of the roof-slope to the horizontal.
$\frac{1}{8}$	$18\frac{1}{2}^{\circ}$
$\frac{1}{4}$	$26\frac{3}{4}^{\circ}$
$\frac{1}{3}$	$33\frac{1}{2}^{\circ}$
$\frac{1}{2}$	45°
$\frac{2}{3}$	53°
$\frac{3}{4}$	$56\frac{1}{4}^{\circ}$
1	$63\frac{1}{2}^{\circ}$

A pitch, for a double-slope roof with corrugated iron covering, which is generally adopted is $\frac{1}{3}$. This slope is steep enough to prevent hail from lying on the roof.

Galvanised corrugated iron covering may, however, be laid much flatter than this, as will be seen from instances throughout this book of single-slope or “flat” roofs.

Thatching requires a steep slope, so as to throw off rain-water before it can penetrate the thatch. This slope should not be less than 45 degrees, and in many cases it is made 50 degrees, with the horizontal.

Types of Roofs.—Ordinary roofs may be divided into two classes, viz.:—

- (1) Single-slope or single-pitch roofs.
- (2) Double-slope or double-pitch roofs.

Single-Slope Roofs.—These roofs are generally referred to by the carpenter as “flat” roofs. Roofs of this class are illustrated by Figs. 86, 87, 88, 92 and 48, and are described in Chap. IX.

Lean-to roofs which consist of a row of rafters arranged to form an inclined plane against a wall, usually of another building, belong to this class.

For a flat or lean-to roof, with corrugated iron covering, the rafters,

spaced not more than 5 feet apart, will require to be of the following sizes for the spans mentioned.

Free span not exceeding—	Size of rafters.
11 feet	4½" by 1½"
14 "	6" by 1½"
20 "	9" by 1½"

By the use of struts such as "A," Fig. 48, the total span may be increased, the clear or free span remaining (in any particular case) the same as that given in the above table.

FIG. 43.

FIG. 49.

FIG. 50.

Double Slope Roofs.—Double slope roofs receive different names according to the construction of their ends. The end of a double slope roof may be built in one of two ways. If terminated by a roof-slope the roof is said to be *hipped* (Fig. 49), but if the end walls are carried up to the peak or ridge of the roof the latter is then called a *gabled roof* (Fig. 50).

A roof hipped at both ends is termed a *pavilion roof*.

Remarks on Roof Trusses.—Reference to the accompanying Figs. illustrating different types of roof trusses, will help the reader to understand the following remarks.

The roof-covering is carried (through the purlins) on a series of rafters. Each pair of rafters in a double-slope roof forms a *couple*. The rafters composing each couple would tend to thrust out the walls on which they rest. To counteract this tendency each pair of rafters is braced by a cross timber, stretching from the foot of one rafter to the foot of the other, and known as a *tie beam* since it ties the feet of the rafters together.

When the span is large and the rafters are consequently long, the latter tend to sag. This is prevented either by the introduction of cross timbers, termed *collars*, higher up the rafters than, but parallel to, the tie beam; or by the insertion of diagonal timbers stretching from tie beam to rafters and called *struts*.

The tie beam, when long, is prevented from sagging by timbers, usually vertical, connecting the tie beam to the rafters. These are termed *king-posts* or *queen-posts*, according as they are at mid-span or quarter-span respectively. They also take up the thrust of the struts.

The rafters (forming a couple) are connected to each other at their top ends by means of a *cleat*, though this is sometimes unnecessary, *e.g.* when the principal in question is provided with a king-post.

Each couple, together with its strengthening timbers such as tie-beam, collar, struts, etc., constitutes a *principal* or *roof-truss* already mentioned.

Wall Plates.—The principals rest on $4\frac{1}{2}$ " by 3" *wall plates*, being attached thereto by strips of hoop iron bent over, and nailed to, the foot of the rafters, and also nailed at each end to the wall plate.

The wall plate is built into the wall along the inside edge of the latter, and is firmly attached to the wall by strips of hoop iron having one end nailed to the wall plate and the other end built into the masonry or brickwork.

The roof is thus protected against being lifted by violent winds.

The wall plates are connected, at the corners of the building, either by a halved joint (Fig. 77), or by dove-tail halving (Fig. 78). The latter type of joint is further illustrated by Fig. 78a.

Roof Trusses for Different Spans.—The accompanying figures illustrate

roof trusses suitable for spans varying from 9 to 38 feet. These spans, together with the *scantlings*, or dimensions of the various timbers, are clearly marked on the figures.

The roofs shown by Figs. 51 and 52 are called collar roofs.

Fig. 53 illustrates a cross-braced roof which is useful when head-room is required along the mid-width of a building.

FIG. 51.

FIG. 52.

FIG. 53.

FIG. 54.

Fig. 54 shows a roof with tie-beam, collar and braces, while Figs.

55 and 128 illustrate a roof of the same type applied to a cottage and cow-byre respectively. In the case of the cottage the tie-beam is supported at mid-span by a party wall, while in the case of the cow-byre the tie-beam derives support from the heel-posts of the stall divisions. This support accounts for the extra distance spanned, beyond the maximum span mentioned under Fig. 54.

FIG. 55.

Fig. 56 is of a king-post roof, while Fig. 127 shows a similar roof (with queen-posts added) employed to cover a cow-byre.

FIG. 56.

Figs. 57, 58, and 59 illustrate king- and queen-post roofs suitable for spans ranging from 24 to 38 feet, while Fig. 130 shows such a roof used for a wide cow-byre. In Fig. 59 note the wrought-iron strap, of U form, bent over the foot of the king-post and tie beam, and bolted through with 3/8-inch bolts.

Notes on Erection.—The timbers to form the principals are assembled and nailed, or bolted, together on the ground. One principal is put together first, and then serves as a pattern or guide for use in constructing

all the others of the same span and type. Bolting is superior to nailing, and should therefore be used for at least the larger sizes of principals. Bolts $\frac{3}{8}$ inch in diameter are generally employed.

FIG. 57.

FIG. 58.

FIG. 59.

Corrugated galvanised iron is procurable in sheets a little more than 2 feet wide, and of lengths from 5 feet, increasing by increments of 1 foot,

up to 12 feet. It is advisable to purchase the iron all of one brand, on account of possible difficulty in fitting sheets of different brands together, due to slight differences in the shape and size of the corrugations.

By "gauge" of the iron is meant its thickness. No. 24 gauge should be used as No. 26 gauge is very thin, and apt to be penetrated by hail-stones.

At horizontal joints the plates should overlap each other by at least 6 inches, the purlin being placed $1\frac{1}{2}$ inches up from the lower edge of the upper sheet, as shown in Fig. 60.

The joints running from ridge to eaves should have an overlap of at least 3 inches, or one complete corrugation (*i.e.* one ridge plus one valley), as shown in Fig. 60.

FIG. 60.

Looking at the right hand view of Fig. 60 it will be seen that the plates in the middle of the view overlap those on each side, on the top of these latter plates. Further, the long edges of the plates in the middle of the view point downwards, and so throw off the rain-water and make it less liable to penetrate the joints. This arrangement should be secured in all such joints; it may be obtained by having *upper* and *lower* plates alternately (along the roof), as shown in the right-hand view of Fig. 60.

The corrugated iron plates are fixed by galvanised iron *roofing screws*, which are driven into the purlins with a hammer (see Fig. 60). Under the head of each screw two washers are inserted, a lead washer below and a galvanised iron washer above. The screws are inserted in holes punched in the *ridges* of the corrugations, not in the depressions. Care should be exercised not to punch the holes any larger than necessary to

just pass the screws. The screws fixing the plates, where they overlap at a horizontal joint, should be arranged as shown in Fig. 60, not more than two corrugations apart. Halfway between those purlins which are situated at each end of a sheet (*i.e.* below the horizontal joints), another purlin—or two, in the case of longer sheets—should be provided. In these intermediate purlins three screws per sheet will suffice; one through each outer ridge, and one through the ridge at the middle of the sheet. It may be mentioned that the purlins should never be further apart than 4 feet 6 inches.

The peak, or ridge, of the roof is protected by galvanised iron *ridging* (Fig. 61). The two topmost purlins should be placed to receive the screws that fix both the ridging and the upper edge of the topmost corrugated iron plates—the joint between these plates and the ridging being arranged similarly to that shown in Fig. 60—and the edges of the ridging should be hammered down so as to follow the corrugations of the iron below. Joints between individual lengths of the ridging should have an overlap of at least 6 inches, and should gape away from the direction of prevailing rain-winds. Ridging is sold in 6-foot lengths and of girth varying from 15 to 22 inches.

FIG. 61.

The peak of the roof may be provided with a 6" by 1" *ridge-board* running longitudinally (Figs. 55 and 57). Though this feature is not indispensable, it is of advantage in supporting and keeping the upper line of the ridging straight.

Ventilation.—Probably the simplest method of insuring good ventilation in cow-byres, stables, etc., is to have the roof open along the eaves and ridge, the latter opening being protected by a raised, curved capping of corrugated iron (see Fig. 62). The openings along the eaves are easily arranged for, either by not carrying the wall above the wall-plate or, though continuing it above the wall plate, stopping it before it quite reaches the corrugated iron roof-covering.

When roofs are provided with ceilings, situated on the under-side of the tie-beams, the interior of the roof between ceiling and roof-covering should be ventilated. Ventilation is usually secured by the provision of slatted or louvred openings in the roof-covering. These louvres are

generally situated at each end of the roof though, in the case of long roofs, cross draughts are often arranged for by the provision of additional

FIG. 62.

louvres situated on the side slopes of the roof, at intervals along its length.

Types of Eaves ; Gutters.—There are two principal types of eaves, viz. *box eaves* and *open eaves*.

The former type may be used in places where no ventilation opening is required along the eaves. The ends of the rafters are trimmed, and a

FIG. 63.

soffit board and fascia board are nailed on to them as shown in Fig. 63. The guttering is fixed, as illustrated, by long screws passing through both sides of the gutter, and screwed into the fascia board. The gutter is prevented from being narrowed by the pressure of these screws by a tube T (Fig. 63), made by

bending a strip of galvanised sheet-iron into the form of a hollow cylinder, inserted in the gutter between the two holes punched to pass the screw. The screw then passes through this tube.

In the case of open eaves the ends of the rafters are cut as shown in Fig. 64, and the guttering is supported by *guttering brackets* screwed to the rafter ends, or to the lowest purlin.

For farm buildings half-round galvanised iron guttering is very suitable. Gutters should be large, and sufficient *down pipes* should be provided to cope with the torrential rains common in South Africa. Nothing less than 4-inch half-round guttering should be

FIG. 64.

used, and 5-inch half-round guttering should be employed for larger roofs. Four-inch half-round guttering should be fitted with 3-inch down-pipes, while 5-inch half-round guttering should have 3½-inch down-pipes. Down-pipes should not be further apart than 30 to 40 feet according to the width of the roof which they serve, being closer together for wider roofs. That part of the guttering which is intended to discharge into a particular down-pipe should have a slope of about 1 inch in 30 feet towards that pipe. Thus there will be high points in the guttering between adjacent down-pipes. Down-pipes may be fixed to the wall by galvanised iron hooks, provided with a spike at one end, driven into the mortar joints. A better method of fixing, however, is to use galvanised sheet-iron bands, the ends of which are screwed to wooden plugs or slips in the wall.

Examples of the general arrangement of gutters and down-pipes will be found in several drawings in this book.

Thatched Roofs.—In thatched roofs small-sized purlins are used, and in order properly to support them the rafters are spaced only 2 feet apart. The purlins are 1½" by 1½" in cross-section, with corners rounded off, and are cut from 9" by 3" deals. They are spaced 12 inches apart from centre to centre. To the purlins the bundles of thatching grass, each bundle approximately of a size which can just be spanned or ringed by both hands, are tied by tarred string about

$\frac{3}{16}$ -inch thick. If reeds be available a 1-inch layer of these, below the grass thatching, is an advantage, as it prevents short or broken grass from falling into the interior of the roof. The reeds may be secured as follows:—About every 3 feet (according to the length of the reeds) a line of thick galvanised wire is laid horizontally along the roof, on the top of the layer of reeds. This wire is attached to the purlins by thinner wires which are tied to it, passed through the layer of reeds, and tied by their other ends to the purlins. These thin wires should be attached at every foot distance along the thick outer horizontal wire. The wires are covered by the grass thatching on top of the reeds, which grass is tied to the purlins by tarred string (as before) passing through the layer of reeds.

Thatched roofs are capped by a ridging made from plain (or flat) galvanised iron sheeting. These sheets have a line of holes punched about 2 inches in from each edge, through which a galvanised iron wire is passed to lace the capping on to the purlins.

Examples of thatched roofs are illustrated by Figs. 148 and 149.

Flashings—In order to render a roof-covering water-tight where it meets a vertical wall, or surface, *flashings* are used. In the case of

FIG. 65.

corrugated iron roofs, the flashings usually consist of plain (or flat) galvanised iron, though they are occasionally of sheet lead.

Referring to Fig. 65, HF is a *horizontal flashing*, and SF is a *side flashing*.

The top edge of the flashing is turned over to the extent of about 1 inch, for insertion and fixing in the joints between the bricks. The

lower part of the flashing is screwed, through the roof plates, either to the ordinary roof timbers, or to special timbers inserted for the purpose in the roof frame-work and called *trimming timbers*.

FIG. 67.—Intersection of two roofs at right angles.

[To face page 65.

Horizontal flashings are in long pieces; side flashings may be either in long or short pieces.

Fig. 65 shows a side flashing in short pieces lapped over each other from 2 to 4 inches. At, and near, the point A, where there is no overlap, a little soldering will be necessary.

Fig. 66 shows a side flashing which is largely used. The upper part, or *apron*, is made up of short pieces, while the lower part, or *under-flashing*, consists of long pieces. This is called a *double flashing*, since it consists of upper and lower pieces. Note how the tail of each of the short upper pieces is held in a slit cut in the adjoining piece, as at B in the drawing.

Note that in all side-flashings, edges such as CD, Fig. 65, are not vertical, but overhang so as to exclude rain.

When a chimney shaft penetrates a roof-slope, the flashing on the upper side of the shaft is formed similarly to that on the lower side, *i.e.* as shown at HF in Fig. 65. It will be evident however, that, in the case of the flashing on the upper side, rain-water would penetrate between the corrugated iron and the flashing HF. This is prevented by laying an *extra* corrugated iron sheet with its lower end on top of the flashing HF, and with its upper end inserted below the upper sheet of the next horizontal joint further up the roof slope or, it may be, below the ridging, if no horizontal joint intervenes.

FIG. 66.

Intersections of Roofs.—Fig. 67 will, if carefully studied, help to make clear the arrangement of the roof timbers and roof-covering at the intersection of two roofs of different span. The drawing is intended to illustrate the intersection of the roofs of the feed-room and cow-byre shown in the frontispiece.

At the intersection of two roof slopes forming a re-entrant angle, a *valley rafter*, VR, of special strength (usually 9" by 1½") is erected. Between the valley rafter and the ridge-board run a series of short rafters, JR, known as *jack rafters*. Along each side of the valley rafter runs a purlin, VP, to support the *valley guttering*, and to which both guttering and roofing plates are screwed. The valley guttering, in this

[To face page 65.]

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FIG. 66.

case, consists of pieces of roof ridging inverted, though it is often formed of plain galvanised iron bent to shape.

The intersection of the roof slopes at the end of a hipped roof is arranged similarly, the valley rafter being replaced by what is known as a *hip rafter* (also 9" by $1\frac{1}{2}$ "). The jack rafters in this case run from the hip rafter to the walls, as indicated in Fig. 49.

The two roof slopes which meet at a hip rafter are capped by roof ridging which is screwed, along with the roofing plates, to two purlins (HP, Fig. 67) running parallel to, and one on each side of, the hip rafter HR. In the case of the roofs shown in this figure the short lengths of hip rafter, HR, are rendered necessary on account of the ridge of one of the roofs being higher than that of the other.

Roofs for Square and Circular Buildings.—Examples of these will be found in Chapters XIX. and XX., which deal with silos.

CHAPTER VII

WOODEN FLOORS AND CEILINGS

WOODEN FLOORS

Ground Floors.—The flooring boards, which form the surface of the floor, are carried by *joists* consisting of quarter-deals, *i.e.* $4\frac{1}{2}$ " by $1\frac{1}{2}$ " scantlings. These joists are carried on *wall-plates* and *sleepers* (see Fig. 68), the former resting on offsets from the walls of the building, the latter on *sleeper walls*. The sleeper walls should be spaced not more than 6 feet apart from centre to centre; they are generally of rough rubble masonry with their upper surface finished off level and surmounted by a damp course on which the 3" by 3" (or $4\frac{1}{2}$ " by 3") sleepers rest. The 3" by 3" (or $4\frac{1}{2}$ " by 3") wall-plates, which support the ends of the joists, are placed on top of the damp-course of the walls, which damp-course should be wide enough to cover the width of the offset.

The flooring joists of ordinary floors are $4\frac{1}{2}$ " by $1\frac{1}{2}$ " in cross section, but when a superior, extra-stiff floor is required 6" by $1\frac{1}{2}$ " joists are used. The joists should be spaced not more than 18 inches apart from centre to centre; if, however, they are spaced only 15 inches apart a much better floor results. In farm buildings in this country the flooring joists are frequently spaced too far apart, producing a weak and unsatisfactory floor.

In setting the flooring joists in position the one nearest to the outside door should be put down first, with its top edge $1\frac{1}{4}$ inches below the door sill. When the 1-inch flooring boards are laid their surface will therefore be $\frac{1}{4}$ inch below the door sill. This allows for a floor-covering such as linoleum. If no floor-covering is to be used the joist in question should, of course, be set with its top edge 1 inch below the door sill, with which the surface of the flooring boards, when they are laid, will consequently be level.

Floors are sometimes laid level with the door sill, even when a floor-covering is to be used, the consequence being that the bottom edge of the

ELEVATION SHOWING AIR BRICK.

FIG. 68.

door has to be planed away to some extent in order that it may clear the floor covering when the door is swung open. This leaves an unsightly and objectionable gap between the door and its sill when the former is closed.

The joist nearest the outside door having been laid as explained, the remaining joists are laid with their top edges level with it. This is done with the aid of a long straightedge and a spirit-level. Any joist, where too high, is lowered by checking out pieces from its under edge, above wall-plates and sleepers. Joists, where too low, may be packed up by thin slips of wood nailed to the top edge of sleeper or wall-plate. The joists are nailed to the wall-plates and sleepers by nails driven at an angle from the sides of the joists; this is termed "stitch nailing."

The flooring boards are commonly 6" by 1" in cross section, and are grooved and tongued. If one of them be examined it will be seen that neither groove nor tongue is in the middle of the thickness of the board;

FIG. 69.

they are nearer one face than the other. The former face should be laid downwards as in Fig. 69. This allows for the wear on the upper surface of the floor. The flooring boards are nailed to each joist, the $2\frac{1}{2}$ " nails used being driven near the joints as shown in the figure. As a rule wall-plates, sleepers, and flooring joists are tarred. The under side of the flooring boards should also be tarred. If white ants are feared the wall-plates, sleepers, flooring joists, and flooring boards, before being tarred, should be well soaked in a solution of corrosive sublimate (HgCl_2) in water, in the proportion 6 oz. corrosive sublimate to 1 gallon water. If a large enough bath, or tank, be not available for this purpose, the wood may be painted two or three times with a solution of corrosive sublimate in methylated spirits in the above proportions. Besides rendering the wood repugnant to ants, this treatment also tends to prevent dry rot.

Ventilation under Wooden Floors.—It is most important that good ventilation should be provided under wooden floors, in order to prevent dry rot. Ventilation is arranged for by building *air-bricks* consisting of

iron grids (Figs. 70 and 71) into the wall at intervals (see Fig. 68). The air-bricks commonly used are 9" by 6" in size, *i.e.* they occupy the space of two bricks. The aperture left in the wall to receive, at its outer end,

FIG. 70.

FIG. 71.

the air-brick is bridged either by a *Welsh arch* (Fig. 72) or by a stone or concrete lintel (Fig. 68). These apertures are situated immediately above

FIG. 72.

the damp course. Air-bricks should be inserted in all four outer walls of a building, and apertures should be left in party walls so as to connect the spaces underneath the floors of the various

apartments and give through ventilation. An examination of the plans for a small cottage, shown in Fig. 214, will make clear the arrangement of air-bricks in outer walls, and of apertures in party walls. The latter are indicated in the ground plan, by the dotted lines crossing the party walls.

Upper Floors.—Fig. 73 illustrates a corner of a specially strong floor designed to bear heavy loads, induced by the storage upon it of materials such as sacks of mealies, etc. Such a floor might, for instance, be put in an apartment above a seed, machine, or other room. If properly constructed the floor illustrated will bear with safety a load of 540 lbs. per square foot of floor surface.

The flooring boards are laid on a series of 9" by 1½" joists, spaced 15 inches apart from centre to centre. They should not be less than

1 inch thick, though $1\frac{1}{8}$ inches is preferable to allow liberally for wear on the floor.

The joists are supported at each end on a $4\frac{1}{2}$ " by 3" wall-plate, built into the side walls, the joists themselves having their ends built in for a distance of $4\frac{1}{2}$ inches. The joists are supported at intermediate points by 9" by 6" beams, such as B, which are placed so that the free span of the joists does not exceed 8 feet. Thus a building 16 feet wide inside would have one beam such as B, running, in mid-width, along the length of the building; while a building 24 feet wide would have

FIG. 73.

two such beams. The ends of these beams rest on 6" by 6" by 14" concrete blocks built into the end walls, the ends of the beams themselves being built in for a distance of 6 inches. The beams are supported, at intervals of not more than 8 feet, by 6" by 6" posts P. Should it not be convenient or practicable to put in these beams in one length, the different lengths should be jointed together as shown in Fig. 76, any such joint being situated near one of the pillars P. The bases of the posts, or pillars P, should be firmly bedded in, and supported by, concrete footings. These footings will, in the majority of cases, form part of a concrete floor.

The joists, being inclined to buckle under the load, must be supported by 2" by 1½", or 3" by 1½" cross struts, as shown, at intervals of not more than 3 feet. This strutting should be introduced in continuous lines, so as to gain the full stiffening effect.

In the case of an upper floor, for instance for a dwelling-house, which has not to bear loads due to stored materials, the 9" by 1½" joists would still be 15 inches apart, but a distance up to 14 feet may be spanned. Cross struts to prevent buckling should be inserted, as in the case of the preceding floor.

An upper floor which is ceiled below is referred to as a *ceiled floor*. The ceiling usually consists of 6" by ½" tongued and grooved boards, nailed to the under side of the joists with small cut nails, 1½ inches long, known as ceiling nails. The junction between ceiling boards and walls is hidden by the *cornice*, which is nailed to the ceiling boards, and also to wooden slips which are built into the wall for the purpose while the wall is being raised. These wooden slips should be inserted so that they project beyond the face of the brickwork by an extent equal to the thickness of the plaster which is afterwards to be applied. The same remarks apply to wooden slips built into the wall to receive the *skirting board* which finishes the lower part of the walls, just above the floor, and protects it from damage. Both cornice and skirting board are nailed in position after the walls have been plastered.

The ceiling of a single-storey building, or of the upper apartments of a two-storey building, is nailed to the under side of the tie-beams of the roof trusses, and also to 4½" by 1½" ceiling joists, one of which is inserted halfway between adjacent tie-beams. In Fig. 214A (roof plan) the ceiling joists are marked CJ. They span from wall-plate to wall-plate just as the roof trusses do.

In conclusion, it should be mentioned that the ends of all joists or beams, which are built into walls, should be tarred, and the wood should be dry and well seasoned, so as to prevent disease such as dry rot. Those surfaces of wall-plates which come in contact with the masonry or brickwork should also be tarred.

CHAPTER VIII

JOINTS IN WOODWORK

THE proper connection of the different timbers used in building work is of importance. In designing and making joints in woodwork the following leading principles should be kept in view:—

1. The joint should be cut, and the fastenings arranged, so as to weaken the timbers which are joined as little as possible.
2. Any abutting surfaces, in a joint, which are subject to pressure or compressive stress, should be disposed at right angles to the direction of that pressure. All surfaces, but especially the above-mentioned abutting surfaces, should be accurately fitted to each other.
3. The fastenings and bolts should be properly proportioned, and arranged to the best advantage. It should be remembered that the boring of a hole to receive a bolt severs some of the fibres of the timber, thus diminishing its strength.

Only a few joints, being those most applicable to farm purposes, will be discussed.

Scarfed or Spliced Joints.—Timbers may be joined, so as to form one long piece, by the use of scarfed or spliced joints.

The simplest type of scarfed joint is illustrated by Fig. 74. Half the thickness of the end of each timber is cut away, and the remaining parts are overlapped and bolted together. This is known as *halving*, and the joint is termed a *halved* or *half-lap joint*. This joint is suitable to resist compression, but any cross, bending, or tensional stress is thrown entirely upon the bolts.

FIG. 74.

The joint shown in Fig. 75 has the surfaces *ab* cut to a bevel. If the bolts are tightly screwed up this bevel helps the joint to resist a pull or tension.

The joint illustrated by Fig. 76 is an *oblique scarfed joint* with splayed ends, which is largely used, especially for lengthening posts or uprights. Besides being suitable for compression it can also,

FIG. 75.

FIG. 76.

independently of the bolts, resist a certain amount of cross or bending stress in one direction.

Another type of scarfed joint, which is sometimes called a *splayed scarf with keys*, is shown in Fig. 77. The joint is tightened by tapered keys driven from opposite sides. It is well suited to resist all four kinds of stress, viz. Compression, tension, cross-stress, and bending.

FIG. 77.

Size of Bolts for the above Joints.—As already pointed out the holes for the bolts weaken the scantlings through which they pass. The bolts therefore should not be larger than necessary; the following sizes are recommended:—

For $4\frac{1}{2}$ " by 3" or smaller scantlings use $\frac{3}{8}$ -inch bolts.

For timbers from $4\frac{1}{2}$ " by 3" up to 6" by 6" use $\frac{1}{2}$ -inch bolts.

For scantlings larger than 6" by 6" use $\frac{5}{8}$ -inch bolts.

Large washers should be placed under both bolt heads and nuts.

As all timber shrinks, the bolts should be examined at intervals, and tightened up if necessary.

Halving.—Halving has already been referred to in connection with the lengthening of timbers. The method may also be employed for the purpose of uniting two scantlings at right angles. This is shown in Figs. 77, 77A, 78, and 78A.

In Fig. 78 the surfaces are bevelled, giving a sort of *dovetail halving*, which is often used for connecting wall-plates at the corners of buildings.

FIG. 77A.

FIG. 78.

WALL PLATES,
DOVETAILED JOINT.
FIG. 78A.

Mortise and Tenon Joints.—Tenon joints are used extensively in framing. A *tenon* is formed by cutting away equal rectangular pieces from each side of the end of a scantling. The middle portion, or tenon, so left is usually given a thickness equal to one third that of the scantling on which it is formed. The rectangular hole, or recess, cut in the other scantling in order to receive the tenon, is called a *mortise*.

Figs. 79 and 80 show two forms of mortise and tenon joints.

Haunched Tenon Joints are illustrated by Figs. 96 and 97. The haunch increases the strength of the joint considerably.

Tenon joints, besides being glued, may be pinned (Fig. 79) or wedged (Fig. 96) with $\frac{3}{8}$ -inch wooden pins or wedges. If wedges are used the mortise is made a little wider at its outer end, to receive them. The wedges or pins are dipped in glue before being driven into place. In outside work, however, white lead is preferable to glue.

Oblique Tenon Joint.—This type of joint is illustrated by Fig. 81. It may be used for the fronts of cattle-sheds, verandahs, etc., when it is desired to space the posts rather far apart. The roof-plate is afforded support between adjacent posts by two oblique struts which are jointed to the roof-plate, and to each post, by the joint under

FIG. 79.

FIG. 80.

FIG. 81.

discussion. An example of this is shown, in the case of an implement shed, by Fig. 86.

A $4\frac{1}{2}$ " by 3" roof-plate would, in general, require to be supported in this way, if the distance between posts exceeds 8 feet.

Very often the mortise and tenon are omitted, the joint between oblique strut and post or roof-plate being otherwise the same as that illustrated.

Bridle Joint.—A bridle joint between a post and a beam or rail is illustrated by Fig. 82. This type of joint should be stitch-nailed, *i.e.* fastened by nails driven at an angle from each side of the post into the beam.

Notching.—Fig. 83 shows a post notched to a beam or rail. This joint is extensively used in constructing timber framing for wood and iron buildings. Like the bridle joint, it also should be stitch-nailed.

Dovetail Joint.—An excellent joint for angular work is made by

cutting a series of dovetail shaped pins on the edge of one board, and a corresponding series of sockets on the edge of the other for the pins to fit into. A dovetail joint is illustrated by Fig 84.

Dowelled Joint.—When it is desired to unite two narrow boards to form a broader one, the joint, besides being glued, is further strengthened

FIG. 82.

FIG. 83.

FIG. 84.

FIG. 85.

by means of *dowel pins* let into holes in each board, as shown in Fig. 85.

Dowel pins are made of hard wood and are usually round in form. They are sometimes used for uniting the flooring boards in high-class floors.

CHAPTER IX

WOOD-AND-IRON BUILDINGS

Wood-and-iron Buildings is the name commonly applied to buildings which consist of a wooden framework carrying, on its outer side, a sheathing of galvanised corrugated iron.

The Framework.—The wooden framework is composed of verticals, or posts, and horizontals, the latter being called rails or plates according to their position. Two “sizes” of timber are commonly used, viz. $4\frac{1}{2}$ ” by 3” and $4\frac{1}{2}$ ” by $1\frac{1}{2}$ ”.

The lowest horizontal is called the *foundation-plate*. It is continuous, and rests, in the case of the best work, on a masonry foundation to which it is attached by $\frac{1}{2}$ -inch holding-down bolts. Each of these bolts is provided with a large square washer, and about a foot length of each bolt, together with its washer, is built into the stonework of the foundation. The foundation-plate should either be tarred, or treated with carbolineum or creosote.

The topmost horizontal is also continuous, and is known as the *roof-plate*.

Between foundation-plate and roof-plate, either one or two horizontals are situated, according to the height of the building. These may be termed *rails*; they are non-continuous, being interrupted by the posts.

The posts are checked or notched into the foundation-plate and roof-plate, while the rails are checked into the posts, as shown in Figs. 86, 87, 88, and 89. Checks are made $\frac{3}{8}$ inch deep when cut in $4\frac{1}{2}$ ” by 3” scantlings, but only $\frac{1}{8}$ inch deep when in $4\frac{1}{2}$ ” by $1\frac{1}{2}$ ” scantlings. Joints between corner posts and foundation- and roof-plates are made similarly to that illustrated by Fig. 161.

In the case of cottages the wooden frame-work is composed of the following scantlings:—

Foundation-plates, roof-plates, corner-posts, and door-posts, all $4\frac{1}{2}$ ” by 3”; rails and all posts other than corner-posts and door-posts all $4\frac{1}{2}$ ” by $1\frac{1}{2}$ ”.

In cottage work the posts or verticals should not be further apart than five feet, but in buildings such as sheds they may be placed much further apart.

If the woodwork be creosoted, the life of a wood and iron building will be considerably lengthened.

The Iron Work.—The iron sheathing consists of sheets of corrugated iron, which are usually continuous from foundation to eaves (Figs. 109 and 112). The sheets of iron are nailed to the horizontals of the wooden frame-work with galvanised iron screws, each of which is provided with a galvanised iron washer and also a lead washer. As is done in the case of roofs, the lead washer is placed below the galvanised iron one.

For corrugated iron sheets up to 8 feet in length, one rail between roof-plate and foundation-plate is sufficient, but for sheets longer than this, two rails should be provided to which, as well as to the roof- and foundation-plates, the iron may be nailed.

As in roof work the sheets of iron are fixed so that *both* edges of alternate sheets lap over on top of the sheets between them. Thus there is an upper and an under sheet alternately, similar to the arrangement shown in Fig. 60. It is desirable that the corrugated iron should be nailed to each horizontal by screws passing through alternate corrugation ridges. It will be found, however, that this method of spacing the screws does not always work out so that we get a screw passing through the joint at each end of a sheet. To effect this object it is occasionally allowable to leave *two* adjacent corrugation ridges un-nailed.

Doors and Windows in Corrugated Iron Buildings.—The manner in which doors and windows are fitted into corrugated iron buildings is dealt with in the next chapter.

Wood-lined Iron Buildings.—In order to make iron buildings less hot in summer and less cold in winter they may be wood-lined. For this purpose ceiling boards, nailed to the inner faces of the timbers composing the framing, are generally used.

Brick-lined Iron Buildings.—With the above object in view, a brick lining may be adopted in place of the wood lining mentioned in the above paragraph. The bricks are laid on their faces, so as to fill up the rectangular spaces between the horizontals and verticals of the timber framework. The brickwork is $4\frac{1}{2}$ inches thick, stretcher bond being employed.

In order to key-in the brickwork a $\frac{3}{4}$ -inch square *key strip* of wood is nailed up the side of each post, so as to be situated in the middle of the thickness of the brickwork lining. The ends of the bricks next the posts are notched to receive this key-strip. Key-strips are not necessary on horizontals; on the other hand, they are extremely useful on door-posts where the slamming of the door tends to shake the brickwork loose.

The bricks are laid so that the resulting brickwork surface is flush with the inner edges of the scantlings composing the timber framework.

Since the brickwork is not exposed to the weather inferior burned bricks, or even sun-dried bricks, may be used.

If burned bricks are used they should be laid in lime mortar, and the inside rendering of the walls should be done in lime plaster.

Sun-dried bricks, if used, would of course be laid in *dagga*, and this material would also be used for the plaster.

In order to hold the plaster to those surfaces of the wood framing with which it comes in contact, any one of the following methods may be employed :—

1. The surfaces in question are studded with flat-headed nails which are left projecting slightly.
2. The timbers are cut into in a downward direction with a chisel, so as to form slightly projecting tags of wood all over the surface to which the plaster can adhere. Evidently this will not be satisfactory in the case of horizontals, for which Method 1 might be employed.
3. Strips of rough metal mesh-work, which are made and sold for the purpose, are nailed on to the wood faces. This forms an excellent grip for the plaster, and is the best device of the three which have been mentioned.

EXAMPLES OF WOOD-AND-IRON CONSTRUCTION.

Implement Shed.—The framing for an implement shed 30 feet long by 14 feet 6 inches wide is shown in Fig. 86.

The clear height, from the ground to the lower edge of the front roof-plate, is 9 feet. The rear roof-plate is 18 inches lower than this, thus giving the necessary slope to the roof.

The masonry foundation has an average width of 18 inches, and is built slightly wider at the bottom than at the top, so as to distribute the weight better. The stonework is carried at least 6 inches above the

Fig. 86.—Framework of wood-and-iron implement shed.

ground surface, and is shown penetrating to a depth of 1 foot into the ground, which will generally be sufficient. Its outer top corner is bevelled off, or “weathered” as it is called.

The $4\frac{1}{2}$ " by 3" foundation-plate is fixed to the masonry foundation by $\frac{1}{2}$ -inch bolts, in the same way as has already been described. This plate is tarred.

The posts of the framework are about 7' 6" apart. They are $4\frac{1}{2}$ " by 3" scantlings, but posts other than corner posts are usually $4\frac{1}{2}$ " by $1\frac{1}{2}$ " in cross-section. The two intermediate posts in front of the shed are carried on hardwood feet consisting of 6" by 6" scantlings. As shown in the drawing, each of these hard-wood feet has a cross-piece (also of hardwood) attached by two $\frac{3}{8}$ -inch bolts to its underground portion. These cross-pieces serve as anchors to prevent the roof from being lifted by strong winds. Both feet and cross-pieces are tarred.

The rails or intermediate horizontals are $4\frac{1}{2}$ " by $1\frac{1}{2}$ " scantlings.

The $4\frac{1}{2}$ " by 3" roof-plates are set on edge and are checked into the upper ends of the posts as shown. Since the four posts along the open front of the shed are spaced more than 8 feet apart, the front roof-plate must have extra support. This is furnished by the diagonal struts shown, which have their ends checked into posts and roof-plate respectively.

The rafters are 6" by $1\frac{1}{2}$ " spaced 5 feet apart.

The purlins are 3" by 2" set on edge.

Only the wooden framework and the foundation of the shed are shown in the drawing. The back and ends are designed to be clad with galvanised corrugated iron. The roof-covering, of course, is also of this material.

Lean-to Shed for Stock.—Very often, cheap shelter for live-stock can be provided in the form of a shed arranged as a lean-to against the wall of another building. The frame-work for such a shed is illustrated by Fig. 87. It is very similar in construction to that of the implement shed which has just been described.

The extreme width of the shed is 11' 6" from the brick wall to the edge of the roofing iron at the eaves. The clear height from the ground to the lower edge of the front roof-plate is 6 feet. This is too low for full-grown cattle, and the shed under discussion is intended for use only for young stock. If full-grown cattle are to be accommodated it is desirable to have this height at least 7 feet in the clear.

The rear 3" by 3" roof-plate (or wall-plate) is bolted to the brick wall by $\frac{3}{8}$ -inch bolts which are provided with large washers, consisting of flat bars of iron about 6" by 2" by $\frac{3}{8}$ ", next their heads, *i.e.* on the

other side of the wall to that on which the wall-plate is situated. This wall-plate is fixed 14 inches higher than the front one, to give the roof the necessary slope.

The posts are all $4\frac{1}{2}$ " by 3", and are provided with hardwood feet and anchors as shown.

FIG. 87.—Framework of wood-and-iron lean-to stock shed.

The rafters are $4\frac{1}{2}$ " by $1\frac{1}{2}$ " and are spaced not more than 5 feet apart.

The purlins are 3" by 2" set on edge.

Two $4\frac{1}{2}$ " by $1\frac{1}{2}$ " rails are provided at each end of the shed, to which the corrugated iron, that closes the ends of the shed, can be nailed. If the shed be for full-grown cattle another post, in the middle of each end of the shed, is advisable.

The construction of the manger, which is of wood and plain galvanised

iron, will be clear from the drawing. The rear rail, and posts, of the framework are nailed to wooden slips inserted in the brick wall.

A cross-section of a large shed for full-grown cattle is shown in Fig. 48.

Piggery.—The drawing (Fig. 88) shows the construction of the frame-

FIG. 88.—Framework of wood-and-iron piggery.

work for a wood and iron piggery arranged as a lean-to against another building. Each pen is provided with an exercise yard in front. The pens are 9' 2" by 8' 8", while the exercise yards measure 9' 2" by 15' 0". The pens, the fences forming the yards, and also the yard gates, are designed to be clad with corrugated iron.

In warmer districts, however, the yard fences should be of some

openly constructed type, for the sake of coolness, and to allow free circulation of air throughout the exercise yard. Thus, the fences in question might be of the open spar type; or pig-netting, or some form of woven or meshwork fencing might be used. Either of the two last-mentioned materials should be protected from the pigs rubbing themselves against it, by a spar nailed in a horizontal position to the fencing posts and situated near to the foot of the fence.

The corrugated iron forming the walls of the pens should not be carried quite up to the roof, so as to allow for ventilation.

In warmer districts, for the sake of coolness, the walls between individual pens, and also those between pens and exercise yards, should be of the dwarf type. Thus, in one instance known to the author, the corrugated iron of these walls extends to a vertical height of only 30 inches above the floors of the pens, but the height is raised another 9 inches by four barbed wires stretched horizontally above the corrugated iron at vertical intervals of $2\frac{1}{4}$ inches. Of course the end walls (of the whole building) are carried up almost to the roof.

No doors need be provided in the doorways between the pens and the exercise yards.

The pens may be provided with flagstone floors. The level of the floor in any pen should be a little higher than the level of the surface of the exercise yard attached to that pen, a step at least 2 inches high being formed at the doorway between pen and yard. The floor of each pen should be sloped so as to drain towards the doorway.

Since, in a building of this class, the roof would probably not be provided with rain-water guttering, it is advisable to flag at least a strip of the exercise yards, about 3 feet in width, immediately below the eaves, to receive the rain-water falling from the roof. Rain-water from the roof, if allowed to fall on the bare earth soon erodes a hollow therein.

Wooden sleeping platforms, about 6 feet by 5 feet in size, should be provided within the pens. They should be capable of being removed from the pens for cleaning purposes, and may consist of open sparwork.

The dimensions of the timbers shown in the drawing are as follows :—

Posts, $4\frac{1}{2}$ " by 3"; rails, $4\frac{1}{2}$ " by $1\frac{1}{2}$ "; fence rails, 3" by 2"; roof plates, 3" by 3"; rafters, $4\frac{1}{2}$ " by $1\frac{1}{2}$ "; purlins, 3" by 2"; hardwood feet for posts, 5" by 5".

It will be observed from these three drawings of wood and iron buildings that the posts are sunk into the ground to a depth of 18 inches to 2 feet, which is sufficient for average ground.

Wood which is to go underground should, of course, be well tarred or charred.

FIG. 90.

Dutch Barn.—The construction of a Dutch barn is illustrated by Figs. 89, 90, and 91.

The posts or pillars supporting the roof consist each of two $6\frac{1}{2}$ " by 3" scantlings, bolted together by $\frac{1}{2}$ -inch bolts. The two scantlings forming any one pillar are not bolted touching each other, but are held

FIG. 89.—Dutch barn.

[To face page 86.

$\frac{1}{4}$ inch apart by a number of hardwood washers of that thickness, and $6\frac{1}{2}$ inches square. Each pillar is firmly anchored by being bolted to a 5-foot length of 7" by 4" rolled steel joist, bedded 2 feet in a heavy concrete foundation block, as shown and dimensioned in Fig. 90.

The roof trusses are of the cross-braced type illustrated by Fig. 53, the rafters being 9" by $1\frac{1}{2}$ ", and the cross-braces 6" by $1\frac{1}{2}$ ". The roof covering is of corrugated iron. It will be noticed that 6" by 3" roof-plates are used, set on edge, and checked into the tops of the pillars. These roof-plates are supported by 6" by 3" diagonal struts at the head of each pillar. Below the roof a *curtain* of corrugated iron is fixed, its lower edge being 11 feet above the ground. The lower part of the curtain is nailed to a 6" by 3" rail, inserted between the pillars and supported from the roof-plate, halfway between the pillars, by a $\frac{1}{2}$ -inch suspension bolt. This curtain not only protects the forage from the weather, but also strengthens the barn against distortion due to wind pressure.

The barn is capable of being extended indefinitely, by adding new bays similar to that shown in Fig. 89.

Each additional bay is placed alongside the existing bay or bays, the roof-ridges of all the bays being parallel to each other, and the pillars between adjacent bays being common to both.

The manner in which the valley, between the roof slopes of adjoining bays, is formed is illustrated by Fig. 91. The ends of the rafters are crossed, above the roof-plate, and 2" by 3" bearers

FIG. 91.

are nailed across them as shown. These bearers carry $1\frac{1}{2}$ -inch planking on which is supported the bottom of the valley gutter, formed from plain galvanised iron sheets. The sides of the valley gutter are supported on the thinner planking shown, which is nailed to the lowest purlin of each roof slope, and to the bottom planking.

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Cheap type of Shed.—Fig. 92 illustrates a cheap type of shed for sheltering implements, or for some similar purpose. The back and ends of the shed are covered in with reeds, held between double wires as shown.

REEDS TIED TO DOUBLE WIRES WITH LACING WIRES.

FIG. 92 (1).

FIG. 92 (2).

The framework is of rough unsawn timber, the only sawn timber used being the purlins and the rails which support the upper tier of reeds.

The timber should be well seasoned by the method explained in Chapter XII., and the parts of the posts in the ground should be well tarred or charred.

CHAPTER X

DOORS AND WINDOWS

Doors

FIG. 93 shows a *braced and ledged door* of an ordinary size, viz. 2' 8" by 6' 8", made of 6" by 1" tongued and grooved boards (flooring boards). For a door of this size 18-inch **T** hinges are sufficiently strong.

A door made similarly, but with the omission of the diagonal braces, is termed a *ledged door*.

FIG. 93.

FIG. 94.

The braces are very effective in preventing the door from sagging at the side away from the hinges.

Fig. 94 shows a braced and ledged door with the braces notched into the ledges, the edges of both being bevelled off, or "chamfered," for the sake of appearance.

A framed, braced, and ledged door is illustrated by Figs. 95, 96, and

FIG. 95.

FIG. 96.

97, from which the construction will be clear. The frame consists of two verticals called styles, and three rails, viz. top, mid or lock, and bottom

rail respectively. The rails are tenoned into the styles, the upper rail having a single haunched tenon, and the other two rails double haunched tenons at each end. These tenon joints are glued and wedged with wooden wedges as shown, the wedges being dipped into the glue-pot before being driven into place. The tongued and grooved boarding (flooring boards) is grooved into the lower edge of the top rail, and also into the styles. It will be noticed that the outer face of the door is

FIG. 97.

FIG. 98.

plane (*i.e.* quite flat), no projections being present to catch rain-water. This door is shown hung on 18" *hook and band hinges*.

A *paneled door* is shown in Fig. 98. The framing consists of three uprights or *styles*, the middle style being sometimes called the *munting*, and three rails:—top, lock, and bottom rail respectively. The *munting* is not continuous, being interrupted by the lock rail. The panels are thin boards used to fill in the spaces in the door framing. Hardwood panels are much to be preferred to those of pine. The panels are held freely in grooves cut in the framing; they are not glued or fixed to the framing in any way, on the contrary, they are free either to contract or

In the case of stables and cow-byres, the lower leaf need not be so high. The brickwork jambs of all doorways through which animals have to pass should be well rounded off; bull-nosed bricks may be used for the purpose.

The door shown in Fig. 99 is constructed of 6" by 1" tongued and grooved flooring boards forming two layers, the boards forming the outer or weather layer standing vertically, and being crossed at an angle by those forming the inner layer. The total thickness of the door after allowing for planing will be a little less than 2 inches. The upper edge of the lower leaf of the door is protected, and moisture excluded, by an iron protector as shown, made from sheet iron.

The upper leaf (not shown) is constructed and hung like the lower one, and its upper edge should have a similar iron protector.

The leaves are hung by 2 ft. *hook and band hinges*, and are provided with 9-inch tower bolts.

In some cases the door frame is extended upwards and the space left between the head of the frame and the upper leaf of the door is fitted with louvre boards, thus providing ventilation even when both leaves of the door are closed, but nevertheless excluding rain and direct draughts.

Fig. 100 details a 4' 0" by 7' 6" braced and ledged door, the tongued and grooved boarding being $1\frac{1}{4}$ inches thick. This door is hung by 2-foot hook and band hinges.

Door Frames.—In dealing with this subject the word "frame" is taken to signify the framework that is fixed to the brickwork surrounding the door-opening and in which the door is hung.

Solid Frames.—Doors in the outer walls of a building are hung in *solid frames* (Figs. 35, 99, and 100) which are usually constructed of $4\frac{1}{2}$ " by 3" scantlings. A solid frame consists of two uprights tenoned into an upper cross piece or *head*. The latter projects beyond the uprights, the projecting pieces or *horns* being built into the brickwork of the wall, and serving to hold the door frame in position.

The bottoms of the uprights are either mortised into a wooden threshold or sill, or, in the case of a concrete sill, have $\frac{5}{8}$ -inch bolts inserted into them, leaving about $2\frac{1}{2}$ inches or half their length projecting. These projecting lengths of bolt (dowels) are bedded into the concrete as shown in Figs. 99 and 100.

The frame is further held by the wooden *holdfasts* shown (see Fig. 40),

which are nailed to the uprights and built into the brickwork; and also by strips of hoop-iron nailed to the uprights and built into the mortar joints between the bricks. These hoop-irons should be tarred and sanded; they are a great advantage, especially in the case of wide doorways through

FIG. 100.

which animals pass. The brickwork immediately surrounding such doors, and other large doors, should be built in *cement* mortar.

The door closes against stop-strips generally nailed on to the uprights, though sometimes formed solid with the latter. (See Figs. 35, 99, and 100.)

Skeleton Frames.—Doors inside a house are usually hung on a frame such as that shown in Fig. 38. The *skeleton frame*, as it is sometimes called, is built up as shown, the various pieces being joined together by tenon joints, and the head attached to the uprights by groove and tongue joints. The skeleton is attached to the wall by nails driven into wooden slips built, where necessary, into the joints between the bricks. There might, for instance, be four such slips on each side of the door opening; they should be built into the brickwork as the wall is being raised. The head of the skeleton door frame is nailed to the two 4½" by 3" lintels (in the case of a 9-inch wall) which span the opening. The frame should project beyond the brickwork by the thickness of the plaster afterwards to be applied. After the plastering is finished, and the plaster has become hard, the *architrave* is nailed to the edges of the skeleton frame, and to the wooden slips already mentioned in the brickwork joints.

The *stop-plank* shown, nailed to the skeleton frame, forms a recess on one side into which the door fits when closed. For the sake of symmetry a similar recess is left on the other side, though in this case there is no door to fit into it. The stop-plank is, of course, carried right up the two sides and across the top of the door-opening.

Direction of Opening.—Inside doors in dwelling-houses should open away from any one entering the room to which the door belongs and, when open, should shield the room as much as possible from draughts.

Bedroom doors should be hung so that, when open, they screen the bed from the view of anyone outside the room.

Outside doors in dwelling-houses generally open inwards, but in farm buildings which house stock outer doors are usually hung so as to open outwards.

The latter doors should be provided with a hasp by means of which they may, when open, be fastened back against the wall, so as to prevent their being banged about in windy weather.

FIG. 101.

Locks.—Two types of lock are in use for dwelling-houses, viz. the *rim lock* (Fig. 101) and the

FIG. 102.

Left-hand rim lock.

FIG. 103.—Right-hand rim lock.

FIG. 105a.

FIG. 105b.

[To face page 97.]

FIG. 105c.

mortise lock (Fig. 102). The latter, on account of its being mortised into the door, is much neater than the former. In ordering, care should be taken to distinguish between right-hand and left-hand locks. The difference is illustrated by Fig. 103. A rim lock is fixed on the inner side of the door, *i.e.* on the side towards which the door opens. The doors in Fig. 103 appear therefore as they would to a person looking from the inside of the apartments to which they belong.

Sliding Doors.—In some positions, such as between a bull-box and its exercise yard, or in exposed windy situations, sliding doors are to be preferred to swing doors.

FIG. 104.

Fig. 104 illustrates a "single" sliding door which, for example, could be used between the bull-box and exercise yard shown in Fig. 147.

Figs. 105 *a*, *b*, and *c* illustrate a "double" sliding door, used when a wide opening is required.

The doors are framed, braced, and ledged, and their construction has already been described (p. 90). The manner in which they are suspended, etc., will be evident from the accompanying figures (Figs. 104, 105 *a*, *b*, and *c*, and 106). Each door runs on a 3" by $\frac{3}{8}$ " wrought iron runner-bar, which is bolted to two 9" by 3" deals built into the walls and crossing the opening for the door. These deals are also bolted to the walls, as shown in Fig. 106, and the bolts used to bolt on the runner-bar serve also to hold the two deals together. The bottom of

FIG. 10

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the door is provided with a groove which runs over a 3" by $\frac{3}{8}$ " wrought iron bar bedded in the concrete sill, and projecting about 1 inch. The bottom of the door should clear the top of the sill by about $\frac{3}{8}$ inch.

The rollers rotate on $\frac{5}{8}$ -inch pins carried by 3" by $\frac{3}{8}$ " wrought-iron "suspender" bars B, which are securely bolted to the styles of the door by $\frac{1}{2}$ -inch bolts, as shown. The bars B are strong enough to resist the thrust of a heavy animal against the door. This is often a point of weakness in the types of rollers bought ready-made which, in consequence, soon get out of working order.

FIG. 106.

The sliding door illustrated by Figs. 107 and 108 possesses some good features. The framework only is of wood, being clad with 24 gauge sheet iron nailed on with either flat-headed nails or wood screws. The bottom of the door is provided with two 1" by $\frac{1}{2}$ " wrought-iron pins which slide in a groove formed by two $3\frac{1}{2}$ " by $2\frac{1}{2}$ " angle-irons bedded in the concrete. These angle-irons are held by a number of $\frac{3}{8}$ -inch bolts, and are kept apart by distance-pieces consisting of short lengths of pipe slipped over the bolts, as shown in Fig. 108. The latter figure shows how the wrought-iron pins are attached to the framework of the door, and also how the angle-irons are bedded in the concrete, etc. This arrangement, of having only a pin at each end of the door running

FIG. 107.

in the groove, allows for warping of the door which, in the case of the ordinarily constructed door, tends to cause jamming.

Doors in Corrugated Iron Buildings.—Fig. 109 shows a ledged outer door.

The door frame consists of two $4\frac{1}{2}$ " by 3" posts A,A, which have their ends checked $\frac{3}{8}$ inch into the roof-plate and foundation-plate D,D; and a $4\frac{1}{2}$ " by 3" head, H, tenoned into the doorposts at each of its ends, the tenons being held by wedges, one of which is shown.

Above the head H is a $4\frac{1}{2}$ " by $1\frac{1}{2}$ " rail,

FIG. 109.

R, to receive the screws which hold the corrugated iron (above the door) and also the protector C. The latter is of plain galvanised iron, and is designed to prevent rain from penetrating between the corrugated iron and the head of the door frame.

FIG. 109.

An architrave, E, is nailed to the door frame, the corrugated iron at each side of the latter being hammered flat for the architrave to lie upon.

The protector C projects about $1\frac{1}{2}$ inches beyond each end of the architrave E, its ends being inserted in horizontal slits cut in the corrugated iron which runs right up and down each side of the door.

It will be observed that each stop-strip is notched out in three places to clear the ledges of the door.

WINDOWS.

Windows are for the purpose of admitting light to the interior of a building; in the great majority of cases they also form a part of the scheme of ventilation.

A window consists of two principal parts, (1) the *frame*, and (2) the *sash* or *sashes*.

The frame may be either solid or hollow; in the latter case it is termed a *box-frame*.

The word sash is used to denote the part which carries the glass. The sashes are attached to the frame in various ways, thus we may have:—

- (a) A solid frame with a *fixed sash*; the window cannot be opened.
- (b) A solid frame with *horizontally hung sash* (or sashes). The sash generally swings on a horizontal axis coinciding with

its lower edge; this type of window is specially suited to buildings in which stock is housed and, elsewhere in this book, is referred to as a *drop back window*. If the sash swings on a horizontal axis at its mid-height, it is said to be *centre-hung*.

- (c) *Vertically hung sashes*. Each sash swings about one of its vertical edges, e.g., in *casement windows* the sashes are vertically hung. Casement windows are specially suitable for dwellings, though they may also be used for certain farm buildings such as dairies, seed-rooms, etc.
- (d) *Box frame with sliding sashes* balanced by weights on cords. This type is suitable for dwelling-houses, and may find a limited use in farm buildings.

FIG. 110.

A solid frame is illustrated by Fig. 110. It is similar to a door frame, and consists of two uprights or posts, a cross-piece or head, and a sill. These parts are either mortised and tenoned together, or the posts are merely checked into the head and sill as in Fig. 110. The ends of the sill and head project beyond the posts, and the "horns" so formed are built into the brickwork surrounding the window opening. The frame is rebated (*i.e.* recessed) all round to receive the sash, which is generally put in from the inside of the building and

opens inwards, being hinged along its lower edge in the window illustrated.

The sash is somewhat difficult to construct, but a stock casement sash can be purchased ready-made and would, of course, be hung with its length horizontal. For this purpose $1\frac{1}{4}$ " by 3" *butt hinges* are used. The lower, or hinge, joint between sash and frame should be shielded by a *water board* (Fig. 111) to prevent rain from driving in. This type of window is highly suitable for stables, cow byres, loose boxes, etc.

The solid frames used for fixed sash windows (a), and casement windows (c), are constructed similarly to the frame just described.

Box-frame windows with sliding sashes can generally be bought ready-made by the farmer. The sashes are balanced by weights that slide inside the box frame, and are attached to the sashes

FIG. 111.

by cords running over pulleys near the top of the frame. The point which is of most interest to the farmer is the building in of the window. This is illustrated by Figs. 37 and 41, and has already been explained in Chapter V. The window-board, lining, and architrave (Fig. 41) are, if present, nailed to wooden slips $\frac{3}{8}$ inch thick built into the joints between the bricks. In building-in the window-frame care should be taken that the wood which forms the outer edge of the box-frame, and is usually thin and weak, is not pressed inwards, thereby causing the balance weights to jam. This is especially liable to happen in the case of stonework, due to spalls being too violently forced into position, near the window-frame.

The space between the soffit of the arch and the top of the window-frame (Fig. 37) is covered by a board, which has its upper edge curved to fit the soffit of the arch. This board is called a *fascia* board; it is screwed to the head of the window-frame.

Sizes of stock Windows.—Cottage casement sashes can be had of the following sizes :—

Number of lights or panes in one sash.	Size of each glass pane.	Approximate overall dimensions.
4	7" × 9"	18" × 23"
4	8" × 10"	19 $\frac{1}{2}$ " × 24 $\frac{1}{2}$ "
4	10" × 12"	23 $\frac{1}{2}$ " × 28 $\frac{3}{4}$ "
6	7" × 9"	17 $\frac{1}{8}$ " × 32"
6	8" × 10"	19 $\frac{1}{4}$ " × 35 $\frac{1}{4}$ "
6	10" × 12"	23 $\frac{3}{8}$ " × 41"
6	10" × 14"	23 $\frac{3}{8}$ " × 45"
6	12" × 14"	28" × 48"
9	7" × 9"	25" × 32"
9	8" × 10"	28" × 35"
9	10" × 12"	34" × 41"
12	7" × 9"	25" × 41 $\frac{1}{2}$ "
12	8" × 10"	28" × 45 $\frac{1}{2}$ "
12	10" × 12"	34" × 53 $\frac{5}{8}$ "

Frames for the above sashes can also be had ready-made.

Certain of the above sashes will be found suitable for windows for cow-byres, stables, loose-boxes, etc.

Sliding-sash windows are supplied in the following stock sizes :—

Number of lights or panes in the two sashes.	Size of each glass pane.	Thickness of sashes (over all).
12	7" × 9"	1 $\frac{1}{4}$ "
12	8" × 10"	1 $\frac{1}{4}$ "
*12	10" × 12"	1 $\frac{1}{4}$ "
12	10" × 14"	1 $\frac{1}{4}$ "
*12	12" × 14"	1 $\frac{1}{4}$ "
12	12" × 16"	1 $\frac{1}{2}$ "
12	14" × 16"	1 $\frac{1}{2}$ "

Those marked with an asterisk are the sizes most commonly used for small cottages.

This type of window can also be had with four, or even only two lights; such windows with large panes should be used only for dwelling-houses, and not for farm buildings where the panes are more liable to be broken and are, of course, more expensive to replace than smaller ones.

Note on Glazing.—In order to fix a glass pane in a sash, a thin layer of putty is first placed on the rebate which is to receive the glass; the latter is then gently forced into position, superfluous putty being thus squeezed out. Next, a few flat brads are driven into the sash, around the pane, to hold the glass in position. The brads are

then covered by an edging of putty (round the pane) which excludes rain and also helps to hold the glass fast.

Windows in Corrugated Iron Buildings.—The method of fixing a box window-frame in a wood-and-iron building is evident from Fig. 112.

FIG. 112.

A couple of $4\frac{1}{2}$ " by $1\frac{1}{2}$ " posts, A, A, are erected about 1 inch further apart than the extreme width of the window-frame, their ends being checked into the topmost and bottommost rails, D, D, to a depth of about $\frac{3}{8}$ inch. Between these posts two rails, B, B, are inserted at a vertical distance apart exceeding the extreme vertical height of the window-frame by about 1 inch; the ends of these rails are checked into the posts to a depth of about $\frac{1}{8}$ inch. The window-frame rests on the lower B rail, so that its outer face projects $\frac{7}{8}$ inch beyond the faces of

the posts A and the rails B. This allows room for the corrugated iron. The window-frame is wedged in position by wooden wedges driven between it and the posts A, and is also stitch-nailed to the rails B.

Rain is prevented from penetrating between the corrugated iron and the top of the window-frame by a protector C, consisting of a strip of plain galvanised iron bent to an angle as shown, and having its upturned part inserted behind the corrugated iron and attached to the upper B rail by the same screws as attach the corrugated iron. The protector C is longer than the window-frame is wide, by about 4 inches, the ends being inserted in horizontal slits cut in the corrugated iron which runs right up and down each side of the window.

An architrave, E, is fitted round the window-frame, to hide the junction of the wood and the iron. It is nailed to the window-frame and to the posts A, A. In driving nails care should be taken

that they do not penetrate the interior of the box-frame, where they might interfere with the balance weights.

A solid-frame window is similarly fitted. Sometimes, however, the solid frame is entirely dispensed with, its place being taken by the posts A, A, and the rails B, B, and the sash being hinged either to the lower B rail, or to one of the A posts.

Lighting Area to be provided in Windows.—Local Government Board Regulations in England require that the total area, clear of the sash frames, of the window or windows in every habitable room of a domestic building, shall be equal to at least *one tenth* of the floor area of such room; and every such window must be constructed so that *one half*, at least, may be opened, and that the opening may extend in every case to the top of the window.

CHAPTER XI

LIME MORTAR—PLASTERING IN LIME AND DAGGA—WHITE-WASHING— PAINTING—DISTEMPERING

LIME MORTAR

ORDINARY mortar, used for binding together stones or bricks in building work, consists of blue lime, sand, and water. The mixing together of these constituents may be performed on a rough platform of wood or old sheet-iron about 10 feet square. The required proportions (1 : 3) of blue lime and sand are measured out on the platform by means of a box measuring, say, 24 inches by 18 inches by 18 inches, or some such convenient size. The lime and sand are now turned over dry, with a spade, until the mixture assumes a uniform colour throughout. Water is added and the mixture is turned over twice wet, and is then piled in a heap, which is covered with sacks and left for from three to five weeks to "season." The seasoning makes the mortar more plastic, and less harsh to use. When seasoning is complete the mortar will be found to have dried out considerably; it must therefore be re-mixed with water just before it is used.

The sand for mortar must be clean and free from clay. It may be tested by rubbing a little in the palm of one hand with the fingers of the other, and noting the extent to which the palm is soiled. Clean sand will not stain the palm.

PLASTERING IN LIME AND DAGGA

Lime Plastering.—The act of plastering is sometimes referred to as *rendering*. Mortar for plastering is prepared in the same way as has just been described for ordinary lime mortar. Like the latter it consists of one part blue lime to three parts clean sand, but the sand should be screened through a number 12 (or 12 meshes to the inch) sieve, and only that which passes the sieve should be used. Although it is preferable that perfectly

clean sand should be used, it is seldom that such is obtainable, there being generally more or less clay present. The presence of *too much* clay results in cracking of the plaster coating as it dries.

Too large a proportion of lime also causes cracking, especially if the sand is clayey, in which case it may be necessary to make the proportions leaner than 1 to 3.

Before applying the plaster to the wall, the mortar in the joints between the bricks should be well raked out with the point of a trowel to a depth of $\frac{3}{4}$ inch. The brickwork and raked-out joints should then be brushed clean, and well wetted to prevent the moisture being absorbed too quickly from the plaster, and also to remove dust which would prevent proper adhesion of the plaster to the brickwork. In applying the plaster to the wet brickwork, it should be well pressed into the raked-out joints with the trowel.

In South Africa, plaster is usually applied in one coat, though in the case of a rough stone wall a sort of preliminary coat is often applied, in order to fill up depressions, before the application of the final coat.

A reference to the Chapter on cement concrete (Chap. XIII., p. 134) will give the reader some idea of the method adopted by the plasterer in applying the plaster.

Plaster on external walls, which has to resist the weather, should not be less than $\frac{1}{2}$ -inch thick, though $\frac{3}{4}$ -inch is to be preferred.

Plaster for Unburned Bricks.—Sun-dried, unburned bricks may be plastered as follows :—

Mix one part cow-dung and two parts sandy loam (by volume thoroughly with water. Allow the mixture to stand for a few days, then mix it up again thoroughly just before applying it to the wall.

The joints between the bricks should be raked out to a depth of about $\frac{3}{4}$ inch, but the brickwork should *not* be wetted before applying the plaster.

Apply the plaster to a thickness of not more than $\frac{1}{4}$ -inch, pressing it well into the raked-out joints, and leaving the surface rough. This first coat should be left until it has become quite dry and hard, which will be in one or two weeks.

A second coat of a similar composition to the first, except that it contains a slightly greater proportion of sandy loam to make it harder when dry, is then applied to a thickness of about $\frac{3}{8}$ inch, and is finished off as smooth as possible with a wooden float.

The work may be finished by a coat of whitewash, or of boiled linseed oil, applied when the plaster has become dry.

If a coat of whitewash is to be applied, it is a good plan to prepare the surface of the plaster to receive it as follows:—

Make a mixture either of cow-dung and water, or of old beer and water, and brush it over the surface of the wall. When this is dry apply the whitewash in the usual way. In this case less salt should be mixed with the whitewash than stated in next paragraph, at least with that whitewash which is to be used for the first coat.

WHITEWASHING

Whitewash.—A good whitewash for general purposes may be prepared as follows:—

Add sufficient water to a paraffin-tinful ($4\frac{1}{8}$ gallons) of white lime (slaked) to give it the consistency of cream.

Dissolve about half a teacupful of salt in water and add it to the lime.

Stir the mixture well and let it stand for a day, then strain it through a very fine sieve.

The salt has the effect of hardening the whitewash as it dries, and tends to prevent its scaling or rubbing off.

Sometimes alum is used instead of salt.

If the slaked lime be mixed in skim milk (instead of in water), neither salt nor alum is necessary.

Recipe for Whitewash used by the U.S.A. Government.—Take half a bushel of unslaked lime and slake it with boiling water; cover it during the process to keep in the steam.

Strain the liquid through a fine sieve and, while hot, stir in the following ingredients:—one peck salt previously dissolved in warm water, three pints ground rice boiled to a thin paste. Add five gallons of hot water to the mixture, stir well, and let stand for a few days covered as nearly air-tight as possible.

The mixture can be coloured by adding ochre, lamp-black, ground keel, or blueing to suit.

Special Whitewash for Dwelling-houses and Dairies.—Take about $\frac{3}{4}$ of a $4\frac{1}{8}$ gallon paraffin-tinful of white lime (slaked) or best whiting (ground chalk). Add clean water to cover the lime or whiting, and let it stand for about half an hour.

Prepare a pint of starch in the same way as is done for linen, and also make a strong solution of soft soap in about a cupful of hot water. Mix the starch and the soap solution together, stir well, and add to the white lime or whiting, at the same time stirring in sufficient water to reduce the consistency of the mixture to that of cream.

A little blue may now be added to improve the whiteness of the mixture.

Next strain the mixture through a very fine sieve and let it stand for about six hours before applying.

A Cheap Whitewash.—The Department of Agriculture of New South Wales recommends the following as a cheap whitewash which will stand rain and weather without coming off, and will do for galvanised iron :—

Place enough tallow required for the purpose in a large bucket, then lay about the same quantity of good lime (dry) on top of the tallow, *i.e.* equal proportions of each; then pour enough water on to slake the lime. When the heat from the lime has melted the tallow, and all is dissolved, stir thoroughly until well mixed; then apply (warm, if possible) with a large brush. This will do for any surface. The surface must be quite dry before applying the mixture. If required to dry very white add a small quantity of blue.

Surfaces, such as those of walls and ceilings, should be washed clean and allowed to dry thoroughly before they are whitewashed.

PAINTING.

Paint protects the more perishable parts of a building against the deleterious effects of alternations of moisture and dryness, heat and cold, gases, etc. It has also a decorative effect, when applied tastefully.

Woodwork should be painted only when the wood is thoroughly seasoned and dry. A coating of paint on partially seasoned or wet wood confines the sap and moisture, and thereby hastens decay instead of retarding it.

The woodwork of first class buildings is given four or more coats of paint, but in buildings of an inferior class often only two or three coats are applied.

Materials used in Painting.—The principal constituent of oil paint is white lead (basic hydrated carbonate of lead). Other constituents

are linseed oil, red lead—used in the first or priming coat, pigments or colouring matters, litharge or other “driers,” and sometimes spirits of turpentine (turps).

The chief constituents perform the following functions :—

Some of the linseed oil soaks into the wood to a certain depth, filling up the pores and finally drying into a substance resembling resin which retards decay by excluding air and moisture.

The remainder of the linseed oil forms, with the white lead, a compound which can be easily spread over the surface of the wood, or other material, forming a protective layer.

The litharge (or other driers) being rich in oxygen, by its oxidising effect on the oil, hastens the drying and hardening of the paint.

Red lead is also rich in oxygen. It is used with the first or “priming” coat, which it causes to dry hard, thus producing a good base for the remaining coats.

Pigments are materials of animal or mineral origin, which supply the colour to the paint. These materials are ground in oil when they are to be used for oil paints; for distemper or water paint they are generally marketed as powders.

Spirits of turpentine is used merely to save oil, and make the paint more liquid and therefore easier to work. Since it evaporates after the application of the paint, it has nothing to do with protecting the wood or other material painted.

Proportions of Ingredients.—The proportions of ingredients differ considerably according to the kind of work to be done, climate, and other circumstances. The following is a rough guide for inside work, assuming the materials used to be of good quality :—

Coat.	White lead.	Red lead.	Raw linseed oil.	Litharge or patent driers.	Turps.	Approximate number of square yds. paint will cover.
First or priming . .	8 lbs.	2 lbs.	4 pints	2 ozs.	—	60
Second	10 „	—	2 $\frac{3}{4}$ „	2 „	1 $\frac{1}{2}$ pints	93
Third and remaining	10 „	—	2 $\frac{1}{2}$ „	2 „	1 $\frac{1}{2}$ „	100

To the last two coats the final colouring matter is added according to depth of tint required, roughly from 1 to 2 ozs. of pigment for every 10 square yards of surface to be coated, the quantity of white lead being correspondingly reduced.

For outside work *boiled* linseed oil should be used for all but the priming coat, and in the third and remaining coats less turps should be used. The following proportions of oil and turps are suitable:—

Priming coat	4 pints raw linseed oil	No turps
Second coat	2½ pints boiled linseed oil	1½ pints turps
Third and remaining coats	3¾ „ „ „	¼ pint turps

If the work is much exposed to the sun it might be advisable to use a slightly larger proportion of turps in the last coat, to prevent the paint from blistering. *Boiled* linseed oil, however, should not be used in white or light-tinted paints where purity of tint is desired, as it causes the paint to dry dark in colour.

Preparation of Woodwork.—The surface of the wood to be painted should be planed smooth and clean, and sand-papered; it should be dry and free from dust. All nails should be punched in until their heads are below the surface.

Killing Knots.—In order to prevent the paint from being discoloured by the resin exuded from knots, the latter are “killed” by painting them over with *knotting*. Knotting is made by dissolving shellac in methylated spirits or naphtha. Knotting is often applied in two coats, but for most farm purposes one is sufficient. *Patent knotting* is largely used; it can be purchased in tins.

Priming.—After the knotting has dried, the priming coat is applied.

Stopping and Painting.—When the priming coat has become thoroughly dry the work is *stopped*. This consists of filling all nail-holes, cracks, etc. with soft putty. The work is again lightly sand-papered, and the remaining coats are applied, each coat but the last being lightly sand-papered before the application of the next one.

In painting, the brush should at all times be held at right-angles to the face of the work, *i.e.* with the ends only of the hairs touching the work. This prevents smearing of the paint, and insures a thin coat of uniform thickness, which is desirable. The latter object may also be furthered, at least in the case of fair-sized and large surfaces, by drawing the brush first across the grain of the wood, and then finishing off *with* the grain, in applying each coat of paint.

Durability.—Paint on external surfaces lasts from three to seven years, according to the quality of the materials employed; and on

interior surfaces from seven to thirty years, according to quality of paint and conditions to which subjected.

Re-painting Old Work.—Old work, before being re-painted, must be thoroughly cleaned. This is done by well scouring the surface with soap and water. If the surface is greasy, lime-water may be used and the work rubbed vigorously with pumice stone. When the surface, after having been scoured, becomes dry, it should be rubbed with pumice stone or sand-paper, and all cracks, etc., stopped with putty. In mixing the paint for the *first* coat for old work, more turps than oil should be used; this gives a paint which will adhere well. The remaining coats would be the same as for new work. Before applying the first coat, any parts of the surface from which the paint has blistered or been knocked off should be brought up to the general level by painting these particular parts only. If it is much blistered, old paint should be entirely removed before the object in question is re-painted. Old paint can be removed by the application of any one of various solutions suitable for the purpose, or by scraping or burning. The above-mentioned solutions usually contain caustic soda, lime, etc.

Wash for Removing Oil Paint.—The following are two recipes for removing old paint:—

1. Dissolve 4 ozs. caustic potash and 2 ozs. soft soap in boiling water and add $\frac{1}{2}$ lb. quick lime. Smear hot over the old paintwork and allow it to remain for 24 hours. The old paint can then be easily washed off with hot water.
2. Mix, with water, 2 lbs. washing soda and $\frac{1}{2}$ lb. quicklime to the consistency of cream. Smear the mixture over the old paintwork and keep moist for an hour. The old paint can then be washed off.

DISTEMPERING.

Distempering Plaster-work.—Distemper, or water-paint, is generally purchased ready-made in the form of a powder which, in order to prepare it for use, need only be mixed with cold water as directed on the packets in which it is put up. Two kinds of water-paint, for external and internal use respectively, are sold. Distemper powder should be mixed with water to the consistency of average cream, and no more should be mixed at a time than can be applied within two hours,

Walls to be distempered should be clean and smooth, and new plaster-work should be quite dry before the distemper is applied to it. Before being water-painted the walls should be given a coat of glue size. When this is dry, apply the distemper with a broad flat brush, starting at the top of the walls and working downwards. In order to work the distemper well into the inequalities in the surface of the plaster, the brush should be wielded in *all* directions, not merely up and down.

Re-distempering.—In the case of re-distempering old walls no size need be used, but the wall should be thoroughly cleaned with a hard brush before the distemper is applied. Nail holes, etc., may be stopped with a little paste, made with the distemper-powder which is to be used and water. Bigger holes must be filled with lime mortar.

Glue Size.—Glue size is made by placing a piece of glue in the glue-pot and covering it with water. When the glue melts it is thinned by the addition of more water, so forming size. A pound of glue makes about a gallon of size.

CHAPTER XII

TIMBER—EXOTIC TIMBER TREES SUITABLE FOR PLANTING IN SOUTH AFRICA —INDIGENOUS TIMBER TREES—WET ROT—DRY ROT

THE timber used for building purposes is derived from trees which increase in diameter by the deposition of successive layers of wood, each new layer being deposited immediately under the bark of the tree. As a rule one layer is deposited in the course of each growing season; though a recurrence, in any one year, of exceptionally warm or moist weather, may result in the formation of a second layer during that year.

FIG. 113.

These layers of wood appear as rings when a tree is cut across, and are called *annual rings*; by counting them the age of a tree can be approximately estimated.

If we look at a cross-section of a tree trunk, we notice a series of radial lines known as *medullary rays*. These form lines of weakness so that, when the wood dries, splitting takes place along them as indicated in Fig. 113.

Silver Grain.—If the wood be cut into planks parallel, or nearly parallel, to the medullary rays, a beautiful figured appearance known as *silver grain* is obtained on the surface of the finished timber. Silver-grain is especially marked in the case of hard woods. The method of cutting trees into planks so as to get the silver grain effect is, however, wasteful of timber, and is carried out only in the production of high-class work such as good furniture, etc.

Heartwood; Sapwood.—As a tree increases in girth the inner wood becomes denser and harder, and sometimes darker in colour, than the outer wood. The former is called *heartwood*, and the latter *sapwood*. It has been customary to specify, in the case of high-class work, that heartwood alone should be used; but as the demand for timber continues yearly to outstrip the supply, it is becoming increasingly difficult to

comply with this condition, and in most cases it can only be approximated to.

Characteristics of Good Timber.—Good timber should be uniform in colour and substance; straight grained; free from large and dead (or loose) knots, shakes (or cracks), and blemishes of any kind. It should be well seasoned, *i.e.* the sap should be entirely absent, and when cut with a saw the saw should not clog and the cut surfaces should not appear woolly or dull; on the contrary they should possess a shiny and firm appearance. Freshly cut surfaces should emit the characteristic odour of the timber in question. The annual rings should be of regular form; narrow rings indicate strength. Timber, when struck, should give forth a clear ringing sound; a heavy, dull sound indicates decay.

Types of Shakes.—Different types of shakes are illustrated by Figs. 114, 115, and 116.

FIG. 114.

FIG. 115.

FIG. 116.

Fig. 114 shows *star shakes*, caused by the shrinkage of the wood in a direction parallel to the annual rings.

Fig. 115 illustrates a common type of shake known as a *heart shake*.

Fig. 116 shows *cup shakes* which are caused by separation of the wood-layers at the junction of two annual rings.

The last-mentioned type of shake is much more serious than the others, which are usually confined to short lengths at the ends of a log, whereas cup shakes may extend for long distances into the log.

Seasoning.—After the tree is felled, some process must be followed in order to get rid of the sap. This is known as seasoning. For the purposes of this book only two methods of seasoning need be mentioned *viz.* :—air seasoning, and water seasoning.

Trees, which are destined to provide timber for building or other farm purposes, should be felled in late autumn or winter, when the

sap is deficient in quantity and under reduced pressure. After felling, the branches should be lopped off.

Water Seasoning.—If water, preferably running water, is available the logs should be *submerged* therein for about a month; in the case of running water, they should be placed with their length parallel to the current and their butts pointing up-stream. Care should be exercised to see that the logs lie well below the surface of the water, so as to prevent their being attacked by fungi and bacteria.

Air Seasoning.—After about four weeks' submersion, the logs should be removed from the water and piled up in a shed where they will be protected from the rays of the sun and from hot dry winds, but nevertheless will have a good circulation of air around and among them. The logs should be stacked so that each one lies horizontally, in the following manner:—

Lay down on level ground a number of logs about 9 feet apart and parallel to each other; these logs are collectively termed "skidding."

On top of these place a second layer of logs (with their lengths at right angles to the lengths of the first set) leaving open spaces about half an inch wide between adjacent logs.

Lay down a third layer (skidding) similar to the first, the logs composing it being placed exactly above those of the first layer.

Arrange the fourth layer similarly to the second, and proceed in this way, putting down layers of skidding and logs alternately, until the head-room available under the roof of the shed has all been utilised.

The layer of skidding next the ground should consist of thick logs, so that the timber of the second layer may be well raised above the ground. The remaining skidding, however, could be of thinner stuff, say 3 inches diameter, to economise head-room, due regard being always paid to the proper circulation of air through the stack.

The whole stack should be carefully, evenly, and regularly built up, to guard against the timber becoming twisted in drying.

Logs from 8 to 12 inches diameter will require about 10 months in the stack (protected from wind and weather) if of hard wood; but if of soft wood half that time will suffice.

If no suitable water is available the first, or water-seasoning process is dispensed with; while the second, or air-seasoning process is prolonged.

Timber, especially if in the form of large balks, shrinks and warps

considerably during the process of seasoning, and may do so to such an extent as to unfit it for practical use. In order to reduce the risk of the timber being spoiled in this way logs, if of any size, are generally cut into scantlings while still green or unseasoned. The scantlings are then stacked for seasoning purposes in a manner similar to that which has already been described for small logs.

Hard Wood; Soft Wood.—Timber is divided by the carpenter into two classes—

1. Hard wood, which is non-resinous, and
2. Soft wood, which is resinous.

The great bulk of the soft wood used for building purposes in South Africa is imported from Norway, Sweden, and Northern Russia, and is known as *Baltic deal*. Strictly speaking, however, the word “deal” refers to the size to which the timber is cut, the common deal in South Africa being 9” by 3” in cross-section. In South Africa, Baltic deals can, as a rule, be readily obtained in lengths up to about 28 feet, although deals over 20 feet in length cost more per running foot than do those under that length.

Oregon Fir.—Oregon fir, also known as Oregon pine, an American timber, can be readily obtained in South Africa in the form of 9” by 3” deals up to 33 feet in length. Oregon fir is, as a rule, very free from knots. If, however, this timber be very dry, parts of it are apt to split, off in working, etc., in the form of splinters. This defect is probably accentuated by the dry climate of the inland parts of South Africa.

Common Scantlings.—In almost any town in South Africa it is possible to have 9” by 3” deals sawn into smaller scantlings as desired. The dimensions given below, which are commonly referred to in practice, are “nominal” sizes, from which actual or finished sizes may differ slightly.

From one deal, two $4\frac{1}{2}$ ” by 3”, or three 3” by 3”, scantlings can be cut. These are used for wall-plates, floor-plates, lintels, and posts for verandahs, sheds, and corrugated iron buildings.

A $4\frac{1}{2}$ ” by 3” scantling can be cut into two $4\frac{1}{2}$ ” by $1\frac{1}{2}$ ” pieces. These are used for rafters, roof-trusses, ceiling-joists, flooring-joists, framing for galvanised corrugated iron buildings, etc.

Four 3” by 2” scantlings can be cut from a 9” by 3” deal. These are used as purlins for corrugated iron roofs, verandah rails, and similar light work.

From a 9" by 3" deal, five 3" by 1½" scantlings can be sawn. These are useful for light framework.

A 3" by 1½" scantling can be cut so as to produce two 1½" by 1½" pieces. These are used for thatching laths and lighter framework.

By sawing a 9" by 3" deal parallel to its broad faces two 9" by 1½", or three 9" by ¾" planks can be obtained.

Other scantlings, sawn from 9" by 3" deals, which are in common use, are the 6" by 3" and the 6" by 1½". The former is used for posts, *e.g.* heel-posts for horse-stall divisions, and the latter for roof trusses and rafters.

Besides being imported in the form of 9" by 3" deals, soft wood is also brought to this country ready finished as skirting boards, fascia boards, architraves, cornices, picture rails, etc., and as tongued and grooved flooring and ceiling boards. The common size of flooring board is 6" by ¾", and of ceiling board 6" by ½", though narrower boards are used for superior work.

12" by 1" shelving boards are also imported. The principal use made of these is as indicated by the name.

Boards of clear pine 1 foot wide by ½", 1", 1½", and 2" thick are imported. They are cut from specially selected timber, and are comparatively free from knots, and therefore suitable for special work, furniture, etc.

Poplar.—Poplar from North America is used for furniture. It is, however, liable to split and warp, especially in warm, dry districts where, perhaps, clear pine is to be preferred.

Hardwoods.—Hardwoods are not much used in farm buildings. In superior buildings, door, and window sills are made of oak or teak. Jarra is used to some extent, *e.g.*, as beams, and fencing and gate posts.

Tree Planting.—While there are certain portions of South Africa which can never produce commercial timber profitably, *e.g.* the Karroo, the Southern and Western Orange Free State, and much of the Western Transvaal, there are still many parts in which such timber will succeed. Care should be taken to select, for planting, those trees which are best suited to local conditions of soil, climate, etc.

A few reasons why a farmer should plant trees are appended:—

1. If planted so as to form wind-breaks, they tend to diminish the evaporation of moisture from cultivated lands, and in this way lessen the evils of drought.

2. If the right trees are planted they provide a supply of valuable timber for fencing, building, and other purposes.
3. They improve the appearance of the landscape in general, and of the farmer's property in particular.
4. They provide a supply of fire-wood, which the thrifty farmer cannot afford to despise.
5. They enhance the value of the property on which they are planted.

The following notes on useful timber trees, which are likely to succeed in particular districts, are largely taken from the records of the Forestry Department.

EXOTIC TIMBERS

Eucalyptus Genus.—In South Africa, the *Eucalyptus* genus of trees is probably the most widely represented, the popular name "gum" being applied to the whole genus.

The Ironbarks.—Probably the most valuable of all the eucalyptus timbers is that provided by the so-called *ironbarks*. This timber is of a dark, rich, red colour, hard, tough, durable, and valuable. It is easily worked considering its hardness and toughness. It stands well in the ground and resists white ants. Ironbark timber is suitable for disselbooms, posts, rafters, beams, joists, waggons, and carts, and forms excellent fencing posts, though it seems almost too good for that purpose.

The ironbarks are four in number—

1. *Eucalyptus paniculata*, popularly called the "white" or "gray ironbark," and termed in Natal the "Torr Vale ironbark," is probably the best of the ironbarks, and therefore stands at the head of all the eucalypts. It is generally quick growing, but cannot stand severe frost; on shallow thorn velds, however, it is somewhat slow growing, and in such districts is not recommended as a timber tree. *Eucalyptus paniculata* has proved successful in—

- (1) Coastal districts in which there is a sufficient depth of soil.
In Natal it is the most popular coast gum.
- (2) Sweetvelds where the soil is deep enough and the frosts not too severe.
- (3) Sourvelds which are not subjected to too severe frosts. On the sugar bush areas of mountain slopes, and doleritic boulder soils, it is the most valuable of the ironbarks.

In general *Eucalyptus paniculata* is the most valuable, fastest

growing, though least hardy of the ironbarks, and should be preferred to any of the others, provided the locality is suitable for its growth.

2. *Eucalyptus siderophloia*.—The common name of this species is "broad-leaved ironbark." It is tender to frost and drought. This tree shows a good, straight growth in the middle districts of Natal.

3. *Eucalyptus crebra*, commonly called the "narrow-leaved ironbark," is slow growing and stands drought and light frost. The timber is straight, and cuts up well. It is a fine tree on the Natal coast.

4. *Eucalyptus sideroxylon*, popularly termed the "red ironbark," is one of the best gums for dry, rocky, and shallow soils, and is hardy against frost. It is neither so well shaped nor so fast growing as *Eucalyptus paniculata*, but is more drought resistant, and is well adapted to cold, dry districts of the Transvaal. The bark is dark and deeply fissured, its rough, ropy appearance being very characteristic. So far as the value of the timber is concerned, *Eucalyptus sideroxylon* stands fourth among the ironbarks.

Other Eucalypts.—*Eucalyptus pilularis*.—After the ironbarks, a tree which ranks high is the "blackbutt" or "flintwood" (*Eucalyptus pilularis*). It is very quick growing, and furnishes hard, durable timber, but is susceptible to frost and drought. It is suited to moist and well-watered lower districts such as Barberton, Swaziland, and coastal areas. It should not be planted in exposed, windy situations. These trees are grown at Tokai Forestry Station. The timber is used largely by the Railway Department for trucks and beams; it does not stand quite so well underground as ironbark timber does.

Eucalyptus maculata, or the "spotted gum," is a handsome, quick-growing, large-leaved tree. The timber is elastic, close grained, and takes on a good finish. It is largely imported and is used for coach-building work, being specially suitable for shafts and wheels. The spotted gum grows well on stony ridges, but is adapted only to localities more or less free from frost. It is one of the quickest growers at Swellendam, Cape Province, and is growing well at Barberton and Tzaneen.

Eucalyptus hemiphloia, or the "gray box," produces a good, strong, durable timber, which stands well in the ground, and is extensively used for sleepers in Australia. It is slow growing, but is one of the best gums for dry country.

Eucalyptus polyanthemos, or "red box," is a good shade tree of medium height. It stands considerable frost and drought, and yields a good, strong wood. It does well in the timber plantations at Vereeniging.

Eucalyptus resinifera, or "forest mahogany" or "mahogany gum," is a valuable timber tree to grow in localities where frosts and droughts are not severe. It produces a good, all-round timber like jarrah. The tree is grown in the Cape Province to provide timber for sleepers, which implies durability.

Eucalyptus rostrata, or "red gum," produces valuable, durable wood. It stands drought, heat, brak, and a good deal of frost. This is the only Eucalypt producing good timber, that will grow on brak lands.

Eucalyptus tereticornis scarcely differs from *Eucalyptus rostrata*, but is generally straighter and better grown than the latter.

Eucalyptus microcorys, or "tallow wood," produces a first-class timber, among the Eucalypt timbers second only to that of the iron-barks. It is used for railway sleepers, and wheelwright work. Being greasy, and not so liable to split as other Eucalypt timbers, it is easier to season. The tree is quick growing, but is suited only to warm, humid districts.

Eucalyptus corynocalyx, or "sugar gum," is a good timber tree which flourishes in a climate of scanty winter rains. It is one of the best gums for the drier, western districts, being easy to raise but tender to frost.

Eucalyptus diversicolor, or "karri," is quick growing, but is not hardy against drought or frost. It produces a valuable timber, which is used for beams, trucks, deckings for jetties, etc. Karri and jarrah are nearly fire-proof, and are used in buildings on that account. Karri is grown largely near the coast, for example at Port Elizabeth and Tokai.

Eucalyptus marginata, or "jarrah," is one of the most esteemed timber trees among the Eucalypts. It has, so far, never been grown successfully in South Africa, but is mentioned here because imported jarrah is in common use.

Eucalyptus globulus, or "blue gum," yields a useful wood which, however, is inferior in strength and durability to that of many other kinds of Eucalypts. The tree should not be planted in very cold or dry localities. The timber requires special care in seasoning, and should be cut up into scantlings within one week after the tree has been felled. It is used to some extent in waggon building, and for

flooring, furniture, etc. South African blue gum timber decays rapidly in the ground.

Besides the above species of Eucalypts, a few other exotic timber trees, suited to South African conditions, may be discussed.

Other Exotic Timber Trees.—*Acacia melanoxylon*, or “blackwood,” is a shade-bearing tree producing strong, valuable timber, which is used for furniture, etc. The timber resembles walnut. The tree should be planted only in the cooler, moister districts, in deep soil. This tree thrives in districts where black wattle (for bark) grows well.

Cedrus deodara, or “deodar,” is a Himalayan tree which thrives best on cold, high lands. Besides being ornamental it produces valuable timber, which is employed in North West India for all sorts of purposes—carpentry, sleepers, bridges, furniture, etc.; in fact it is the most important timber tree in that part of India.

Cupressus lusitanica, or “Portuguese cypress,” is a handsome, quick-growing tree, which requires a moist situation and not too much frost to succeed. It produces good timber.

Cupressus sempervirens exists in two varieties, viz. :—

1. *Var : horizontalis*, or “common spreading cypress,” and
2. *Var : pyramidalis*, or “common upright cypress.”

It is a hardy tree frequently planted in the Karroo. It prefers limestone, and well-drained soils, and produces a first-rate timber which, when mature, is nearly as durable as sneeze-wood. *Var : horizontalis* should be planted in preference to *var : pyramidalis*.

Grevillea robusta, or “silky oak,” is a handsome, ornamental timber tree, which does best with summer rains and semi-tropical temperatures. It yields a light, handsome wood with a grain like oak, and is suitable for furniture making, for which purpose it is largely employed in Natal. The timber is ant-resistant.

Pinus palustris, or “long-leaved pitch pine,” is a very valuable timber tree. It requires deep, sandy or gravelly soil, and a rainfall of from 30 to 40 inches. It will not tolerate shade. This tree is suited to the Eastern Transvaal, and is growing well at Belfast.

Pinus canariensis, or “Canary Island pine,” is hardy against drought, but tender to severe frost. It thrives in mountain climates. It produces the most valuable timber of the common pines.

Pinus halepensis, or the “Jerusalem pine,” or “Aleppo pine,” is very hardy against drought and frost. It does best with winter rains, and

grows on shaley and calcareous soils. The timber is white with a fine grain, but is not quite a first-class timber.

Callitris robusta, or "white cypress pine," is a slow growing tree producing durable, ant-resistant wood. It is suited for dry country planting, especially in sandy soil, and stands fairly severe frost. This tree is suitable for wind-breaks. The timber is prettily figured.

INDIGENOUS TIMBERS

There are a few, more or less useful, indigenous timbers produced in South Africa. The trees which furnish these timbers, however, cannot be successfully grown in regions other than their natural habitat, hence the most the forester can do is to improve the existing indigenous forests, which stretch in a much broken belt along the coastal mountain slopes from Cape Town to the North-east Transvaal. These indigenous forests are commonly called "yellow-wood forests," since yellow-wood is the only large timber tree present.

The following indigenous timber trees are of commercial importance :—

1. *Podocarpus elongata*, and *Podocarpus thunbergii*, or the "large" or "Outeniqua yellow-wood," and the "small" or "upright yellow-wood," respectively.

These two yellow-woods were extensively used by the early colonists for building purposes. The Knysna forests produce a large amount of this timber, which is used for sleepers, being creosoted for that purpose. It is much esteemed for flooring boards. Horses will not chew yellow-wood, and for this reason it is sometimes employed for mangers, and the upper rails of stall divisions in stables.

2. *Ocotea bullata*, or "stink-wood," is the most valuable of all the indigenous timbers. It emits a strong odour when worked. The stink-wood tree is rarely large. Stink-wood is used in waggon-making, and for felloes, cart-poles, swingle-bars, neck-bars, ox-yokes, and furniture. Stink-wood furniture is costly, but very beautiful.
3. *Olea laurifolia*, or "black ironwood," may be classed as a medium-sized, and in some cases a large, tree. The wood, as is indicated by the name, is extremely hard, but is not

durable in the ground. It is used in waggon-making and for disselbooms, long-waggon, swingle-bars, beams, etc. Iron wood is very heavy and will not float in water. Beams as large as 20" by 36" by 12 feet long can usually be obtained without difficulty.

4. *Pteroxylon utile*, or "sneeze-wood," is a small tree with very hard timber, which is almost imperishable in the ground, and hence is highly prized for fencing posts. It has the disadvantages of being irregular in growth (crooked, twisted, etc.), and difficult to work. Large logs can be obtained. The name comes from the tendency to sneeze induced in persons working the wood, owing to its dust and peculiar odour.
5. *Callitris arborea*, or "Clanwilliam cedar," is the most generally useful of all the indigenous timbers. It is as easy to work as Baltic deal, seasons well, is very durable, and has a lasting fragrance. This tree thrives only in its native home in the Cedarberg country, about 120 miles north of Cape Town.
6. *Curtisia faginea*, the timber of which is called "assegai wood," is a medium-sized tree. Assegai wood is prized for waggou-making, spokes for wheels, etc.
7. *Apodytes dimidiata*, or "white pear," is a medium-sized tree, the timber of which is used in waggon-making, and for felloes, etc.
8. *Olea verrucosa*, or "wild olive," furnishes good fencing posts.

DECAY OF TIMBER

Timber is least affected by decay when it is kept dry, and in a well ventilated atmosphere. Some varieties, when kept completely and continuously submerged in water, last almost indefinitely.

Conditions which induce decay in timber are the presence of sap, lack of efficient ventilation, and exposure to *alternating* wetness and dryness.

Wet Rot.—The common rot, affecting timber which is alternately wet and dry, is called "wet rot." Wet rot affects only the surrounding timber actually in contact with it, and if the bad part be cut away the remainder of the wood will be found to be quite sound. Wet rot, unlike "dry rot," is not malignant.

Preservative Processes.—Several processes are in use for preserving timber from decay, such as—

1. Painting, tarring, varnishing, oiling;
2. Creosoting, *i.e.* extracting air and moisture from the wood and replacing them with oil of tar, forced into the wood under pressure;
3. Impregnating the timber with solutions of certain substances such as corrosive sublimate, zinc chloride, copper sulphate;
4. Charring the surface of the timber. Timber which is to be put into the ground is often charred, as an alternative to tarring.

Dry Rot.—Dry rot is a disease of timber caused by the fungus *Merulius lacrymans*, which destroys the fibres of the wood and reduces it ultimately to dry dust.

The conditions most favourable to the occurrence of dry rot are a warm, moist, still atmosphere, and the presence of green sap in the timber, *i.e.* the timber not properly seasoned. The fungus soon dies in the presence of plenty of fresh air.

The germs of the fungus in question are supposed to be brought from the forest in cracks in the timber. Spores from the fungus growing in dry-rot infected wood float about in the atmosphere and, finding a lodgment in sound timber, attack it, provided the conditions are favourable to the growth of the fungus. In this manner, sound timber may become infected, even though it is not in direct contact with diseased timber.

The fungus, when of strong growth, looks like mildew on the wood, and gives rise to an unpleasant, musty smell.

Prevention of Dry Rot.—To prevent dry rot use only thoroughly seasoned wood, and so fix it that the circulation of fresh air around it is as good as possible.

The tarring, or creosoting, of thoroughly seasoned timber fortifies it against infection.

Dry rot is particularly apt to attack ground floors. In Chapter VII, the arrangements suitable for ventilating the space under such a floor are described. As a further precaution the wall-plates, joists, sleepers, and the under faces of the flooring boards should be well tarred, the tar being applied hot so as to increase its penetration into the wood. It is advisable to have no timber nearer than 6 inches to the surface of

the ground. If the above precautions are observed there is little danger of the decay of timber used in the construction of ordinary buildings.

To prevent the occurrence of dry rot when timber is to be placed in positions favourable to attack, the following methods are applied:—

1. **Creosoting**, or impregnating the seasoned timber to a certain depth with oil of tar. This may be done by soaking the wood in hot oil of tar for some hours.

A better method, which secures greater penetration, consists of placing the seasoned timber in an iron vessel which closes air-tight. The air is then exhausted from the vessel, so that the timber in it is subjected to the action of a partial vacuum. Next, the creosote is forced in till the pressure in the vessel rises to over 100 lbs. per square inch. The whole process lasts only 2 or 3 hours. At Knysna, sleepers are creosoted in this way in order to increase their durability. Even when the creosote is forced into the pores of the wood under pressure, it does not penetrate to the centre of a sleeper.

2. A solution of corrosive sublimate (HgCl_2) in water—or, better, in methylated spirits—in the proportion of 6 ozs. sublimate to 1 gallon water, or spirit, applied to the timber, is considered an effective wash. This wash also makes the wood *repugnant to white ants*.

Treatment of Timber affected by Dry Rot.—If timber is affected by dry rot it should either be wholly removed, or at least affected pieces should be removed, according to the extent to which the disease has spread. Timber which is not removed should be thoroughly painted over several times with the wash of corrosive sublimate already mentioned. *All* surroundings, such as brickwork, stonework, etc., should be well sprayed with the same solution, special care being devoted to places which were in contact with the decayed timber as, for instance, holes in the walls in which the ends of beams rested. New timber, put in to replace that removed, should be treated either with corrosive sublimate or creosote.

Besides taking the above precautions, the ventilation should be improved as much as possible, *e.g.* by the insertion of air-bricks in the case of ground floors.

CHAPTER XIII

CEMENT—CEMENT CONCRETE—REINFORCED CONCRETE—REINFORCED CONCRETE FENCING

Portland Cement.—Portland cement is made from a mixture of calcium carbonate and silicate of alumina.

Materials which contain calcium carbonate and silicate of alumina are mixed in relative quantities, such that these two substances form suitable proportions of the mixture.

Calcium carbonate occurs in the forms of lime-stone and chalk.

Silicate of alumina, more or less free from impurities, occurs as clay and shale.

The process of manufacture of Portland cement includes the following operations :—

1. Pulverising and mixing the ingredients.
2. Roasting or calcining.
3. Grinding to a fine powder.

When limestone or chalk (CaCO_3) is calcined, lime (CaO) is produced. The presence of clay, or more correctly of the silica (SiO_2) contained in the clay, renders the cement “hydraulic,” *i.e.* capable of hardening under water.

The name “Portland cement” was conferred by its inventor Joseph Aspdin of Leeds, who gave the cement that name on account of the resemblance of artificial stone made with it to the Portland stone, largely used in England in his time. The date of Aspdin’s invention was 1824.

Cement Concrete.—Cement concrete is an artificial stone, made by mixing cement with an *aggregate*, which commonly consists of broken stone and sand. The sand fills the voids between the stones, while the cement, besides binding the whole together, fills the voids between the separate grains of sand.

Sand.—The sand should be clean, *i.e.* free from loam or clay, and

coarse. It should also be free from all organic matter. The sand is a most important constituent; to use dirty, unsuitable sand is often tantamount to wasting good cement. To test a sand roughly for cleanness, rub some of it in the palm of one hand with the fingers of the other, and note the extent to which the palm is discoloured. River sand is generally very suitable, as it is washed clean by the flow of the water in the river. Dirty sand may be artificially washed on a fine-meshed screen. The water carries the clay through the screen, while the clean sand is left on top.

Coarse sand makes a much stronger concrete than does fine sand. Hence, if the use of fine sand cannot be avoided, the concrete should be made richer, *i.e.* the proportion of cement should be increased. The best sand is that which contains all sizes of grains, up to particles that will just pass a $\frac{1}{4}$ -inch square mesh.

Stone.—The broken stone should be of a hard close-grained quality. It may be used as it comes from the crusher (crusher-run), but it is preferable to screen out the fine particles. The latter may, if desired, be used as a portion of the sand. For mass work, stone which passes a $2\frac{1}{2}$ -inch ring, or even as high as a 3-inch ring, may be used; for floors the stone should pass a $1\frac{1}{2}$ -inch ring; for reinforced concrete the stone should be capable of passing a $\frac{3}{4}$ -inch ring.

In the body of a thick concrete wall, such as a dam wall, large, sound, clean stones may be imbedded without detriment to the structure. Such work is sometimes called "Cyclopean masonry."

If gravel be used it should be thoroughly clean. A layer of clay or dirt on the stones comprising the gravel prevents adhesion between the cement and the stones, and weak concrete is the result. Concrete made with gravel is, as a rule, slightly less strong than concrete made with broken stone.

Setting.—The hardening of cement is spoken of as "setting." Cement concrete goes on hardening for an indefinite time after it has been made. The setting or hardening is due to a process of crystallisation of the cement. Since crystallisation proceeds more perfectly when the material is undisturbed, it is important that concrete should not be shaken, jarred, or interfered with while the initial setting is taking place. The rate at which crystallisation proceeds depends on temperature, thus cement sets much quicker in hot, than in cold weather. It is therefore advisable to use a little extra water when mixing concrete during hot weather, as

otherwise the setting may have proceeded undesirably far before the workmen have had time to deposit the concrete in place.

If the concrete is to set properly so as to form a strong mass, it must be kept moist for at least ten days after laying. This may be done either by spraying the concrete with water twice a day, or by covering it with wet sacks which are re-wet whenever they begin to dry. In the case of more or less level surfaces, after the concrete has become a little hard, the wet sacks may be replaced by a layer of moist sand. The sacks are thus relieved for duty elsewhere. These precautions also serve to protect the "green" concrete from the injurious effects of exposure to hot sun, drying winds, and frost.

Growth in Strength.—The strength of concrete continues to increase for years after it has been laid. Up to an age of two or three months the strength increases rapidly, but after that age the rate of increase in strength is very slow. For this reason concrete should not be subjected to stress too soon. Thus a reinforced concrete tank or silo should not be filled for at least two months after the *last* concrete has been deposited. Neither should earth be filled against a "green" concrete wall.

Proportions of Ingredients.—For important works careful experiments are carried out, with the object of so proportioning the ingredients as to obtain a concrete of maximum density, maximum density having been found to correspond to maximum strength.

For small works, however, such elaborate experiments are dispensed with, and arbitrary proportions are adopted according to the class of work, the ordinary rule being to use twice as much broken stone as sand.

A "rich" concrete is one in which the percentage of cement is high. When the percentage of cement is low, the concrete is spoken of as "lean."

The following mixtures differ only in the relative quantity of cement in each:—

1. Proportions of $1 : 1\frac{1}{2} : 3$, *i.e.* 1 barrel packed Portland cement, to $1\frac{1}{2}$ barrels loose sand, to 3 barrels loose broken stone, is called a rich mixture, and is employed for parts requiring exceptional strength, or water-tightness, or both.
2. What might be called a standard mixture is given by the proportions $1 : 2 : 4$. It is suitable for engine foundations, reinforced concrete work, tanks, conduits, and other water-tight work.

3. Proportions of 1 : 3 : 6 give a lean mixture which should only be employed for large mass work, or as a backing to stone masonry.

If the proportions be fixed by the experiments already referred to, leaner mixtures than the above may be used; this is called "scientific proportioning."

Quantities of Material.—We may look upon the ideal proportions of concrete as being such that there is sufficient sand present just to fill the voids between the stones, while the amount of cement used slightly exceeds that which is necessary just to fill the voids in the sand. The excess of cement is required to coat each grain of sand and each stone, so that the mass may be properly bound together.

It may here be stated that, if the stones are unscreened or just as they have come from the crusher, being of all sizes, say from $\frac{1}{4}$ inch up to 2 inches, less sand will be required than if the stones were all of uniform size. This is because the smaller stones partially fill the voids between the larger ones. As a consequence, less cement also is required.

In the same way, if the sand contains a large variety of sizes of grains, less cement is required than if the grains of sand are all of one size.

If the sand and cement exactly filled the voids between the stones, we might expect to get the same volume of concrete as we had of stone to commence with, notwithstanding that we have added sand and cement. As, however, the cement and sand are in excess of the voids between the stones, we always get a volume of concrete larger than that of the stone with which we started. Thus to produce 1 cubic yard of concrete we will require less than 1 cubic yard of broken stone.

The following table gives the materials required to produce 1 cubic yard of concrete in various proportions:—

Proportions.	Cement. Barrels.	Sand. Cubic yards.	Broken stone. Cubic yards.
1 : 1½ : 3	2·00	0·42	0·84
1 : 2 : 4	1·57	0·44	0·88
1 : 2½ : 5	1·29	0·45	0·91
1 : 3 : 6	1·10	0·46	0·93
1 : 4 : 8	0·85	0·48	0·96

In the above table, a barrel which contains 376 lbs. of Portland

cement is taken as the unit. A bag of Pretoria cement contains 188 lbs. nett of cement, or just half as much as the above size of cask. Examples of the use of the table will be found in Chapter XXVI.

Mixing.—In this country it is advisable to mix concrete rather wet especially if water-tight work is called for. In work of the latter class, if the concrete runs off the shovel unless handled quickly, it will be of about the correct consistence. The materials may be mixed on a platform of iron sheets, or of wood having a raised border formed by a strip of 2" by 3" timber nailed round the edge, to prevent waste of water and materials. On this platform, the correct proportions of sand and cement should be measured out, the former by the use of a cask or measuring box (without top or bottom), and should be turned over three times dry, or until the mixture assumes a uniform colour throughout.

The measured quantity of broken stone is now added, being measured by the box or cask that was used to measure the sand.

The mixture is then wetted with water applied by a watering can with a rose, and is turned over three times wet. Care should be taken that none of the fine cement is washed away while water is being added. To prevent this the mixing platform should be more or less water-tight.

In turning the mixture, either dry or wet, it should be shovelled from one pile into a distinct and separate new pile, and then shovelled back again on to the site of the original pile; by proceeding in this way we can be quite sure that every particle has been turned over the required number of times.

As concrete begins to set in from 30 to 60 minutes (in the case of ordinary slow-setting cement) after it has been mixed wet, it is most important that it should be deposited in place and rammed before the initial set commences. Concrete should therefore be mixed in small quantities as required, and deposited at once, so as to catch the initial set of the cement in the wall or work under construction.

Forms.—The great advantage possessed by concrete lies in the facility with which it can be moulded, or formed, to almost any desired shape.

For a plain wall, the forms may be made of horizontally placed, tongued and grooved boards called *sheeting*, nailed to verticals called *studs*. Flooring boards are suitable for the sheeting, and in many cases

the studs consist of 2" by 3" deal (see Figs. 187 and 182). In the case of 1-inch sheeting, the distance between adjacent studs should not exceed 2 feet. For 1½-inch sheeting the distance between studs may be as much as 4' 6".

The forms should be practically water-tight, and they should be well braced against the pressure of the concrete and the ramming.

If a smooth face be desired on the finished concrete-work, the face of the forms must be dressed with a plane; but when the work is to be plastered there is no necessity for this, since a rough face is desirable in order to hold the plaster.

White-washing, greasing, or oiling the faces of the forms will prevent the concrete from adhering to them. Metal forms should always be oiled.

If there be no external pressure on a wall, the forms can be removed whenever the concrete has become too hard to be indented by the thumb. This will usually be in less than 24 hours. If, however, there is earth or water pressure on a wall, the forms should be securely braced against it, and may have to be left in place for 3 or 4 weeks. While the forms are being removed care should be exercised against injuring the concrete work by excessive hammering, etc.

Depositing.—Concrete is placed between the forms in layers of from 6 inches thick for a very dry mixture, to 15 inches thick for a very wet mixture. Each layer should be well rammed or jogged, so as to compact the concrete and expel air. In the case, however, of a very wet mixture, there is danger of too much ramming causing the fine materials, viz. the sand and cement, to work towards the surface and leave the stones at the bottom. A dry mixture may be rammed with a large, flat-faced rammer till the water flushes to the surface (as in the laying of concrete floors), but in the case of a wet mixture most of the working should consist of jogging with a crow-bar or narrow-faced rammer.

Contraction.—Concrete contracts while setting, giving rise to unsightly cracks.

The formation of *large* cracks may be prevented by reinforcing the concrete, say with steel rods or barbed wire running parallel to the length of the wall. The effect of such reinforcement is to distribute the cracking so that, instead of one or two wide cracks being formed, a large number of minute cracks, which do not matter, are produced, distributed over the length of the wall.

Contraction in a wall may also be provided for by vertical joints at intervals, which divide the wall into separate sections. As each section contracts these joints widen; in effect we are confining the cracking to straight lines. Such joints may be made by moulding the wall in sections, and allowing one section to set before the adjoining sections are filled in. This results in a weak junction between new and old sections. Sometimes the sections are toothed into one another, or tongued and grooved. That is to say, in the end of one section a vertical groove is formed, into which a projection on the adjoining section fits.

If it be desired to make perfectly sure of localisation of the contraction we must insure complete separation of adjoining sections by inserting some foreign material between them. This may be done by leaving a half-inch space between the tongued and grooved ends of adjoining sections, and filling it in with pure asphalte.

Experience seems to teach that, in the case of thin walls, contraction joints should be provided about every 30 feet. In thick walls the joints may be further apart.

In order to limit contraction-cracking to straight lines, in the case of concrete floors, such floors are laid in squares of about 4 feet side, any one square being allowed to set before adjoining squares are laid. In most cases, however, it is considered sufficient to divide up only the plaster or granolithic, with which the floor is finished, into squares of the above size.

Facing Concrete Surfaces.—In building work, walls are often plastered or “rendered.” The usual mortar employed for plastering consists of 1 part cement to 3 parts clean sand; but for surfaces on which animals have to walk, or where water-tightness is required, the proportions had better be 1 cement to 2 sand. The sand should be screened through a 12 mesh sieve, that which passes through the sieve being used.

A good surface for a floor is formed by a *granolithic finish*, which is applied in two layers, as follows:—

- (1) A layer about $\frac{3}{4}$ inch thick, consisting of 1 part cement, to 1 part clean sand, to 3 parts granite chips capable of passing a $\frac{3}{4}$ -inch square mesh.
- (2) An upper layer $\frac{1}{4}$ inch thick, consisting of 1 part cement, to 2 parts granite chips capable of passing a $\frac{1}{4}$ -inch square mesh.

An ordinary finish for a floor consists of 1 part cement to 2 parts sand, applied in a layer from $\frac{3}{4}$ inch to 1 inch thick. This requires much more cement than does a granolithic finish.

It is most important that any layer, such as plaster or granolithic, should be applied while the base concrete which it covers is still "green," in order to get as good adhesion as possible. Thus in laying, say, a cow-byre floor, it is advisable only to lay as much in one day as can be completely finished off and surfaced on that same day.

The following description of the rendering of a vertical wall may help to make clear the method adopted by the plasterer :—

The "green" concrete of the wall is first scratched all over with an iron spike, or the point of a trowel, so as to produce a rough surface. The workman next proceeds to apply vertical strips of cement mortar, about 4 or 5 inches wide, to the wall. These strips are spaced about 3 feet apart. The surface of the wall, where each strip is to be placed, is wetted and painted with neat cement grout (*i.e.* cream of cement and water) *immediately* before the application of that strip.

The strips, having been applied to the wall, are next scraped off plumb and reduced to the correct average thickness by the use of a wooden straight-edge, a spirit-level being employed to test their plumbness. These strips of mortar are called *screeds*; they serve as guides for the working of the remainder of the plaster between them, a straight-edge extending from screed to screed being utilised for that purpose. The surface of the wall between the screeds is wetted and painted with neat cement grout, immediately before the application of the cement plaster, as was done for the screeds themselves. In applying the mortar, both for screeds and intermediate portions, the first of it should be *thrown* on to the prepared surface of the wall; by this means effective adhesion is secured.

The whole surface of the plaster is smoothed by rubbing it over with a wooden float, and the final finish is given some time later, by means of a steel float, when the plaster is hard enough not to stick to the float and so be torn away from the base concrete. This trowelling with a steel float brings the cement to the surface, thus producing a dense hard face and increasing the water-tightness.

Surfaces on which animals have to walk, should be rough finished by brushing them over with a stiff brush while the face is still soft.

Plaster should be sprayed twice a day with water, for about ten

days after its application, while floors should be kept covered with wet bags or moist sand, for a like period after surfacing.

The most serious objection to plastering is that proper adhesion of the plaster to the base concrete is not always secured. A method of facing which overcomes this objection consists of "spading" between the concrete and the form, immediately after the concrete has been deposited. The spade is passed down between the concrete and the form, the object being to press the stones back and thus allow the cement and sand to flow towards the form and produce a dense, smooth face. Care should be exercised, while spading, not to prise the form out of place. A hardwood spade, as shown in Fig. 174, may be made for the purpose, though an ordinary spade will suffice, a narrow one being preferable.

Various washes have been tried from time to time with the object of rendering concrete water-tight. One which has proved successful in some cases consists of 1 pound concentrated lye, 2 to 5 pounds alum, and 2 gallons water.

In calculating the approximate quantities of materials required for plaster, the following table may be used :

MATERIALS FOR 1 CUBIC YARD COMPACT, PLASTIC MORTAR, MADE WITH FINE SAND.

Proportions by volume.		Packed cement.	Loose sand.
Cement.	Sand.	Barrels.	Cubic yards.
1	1½	3·72	0·78
1	2	3·12	0·88
1	2½	2·69	0·95
1	3	2·37	1·00

NOTE.—The above barrel contains 376 lbs. nett of cement.

An example of the use of the above table will be found in Chapter XXVI., pages 282-3.

Bonding Old and New Concrete.—In the case of thin walls (for instance those of a water-tank or dipping-tank, which have to be water-tight, or those of a silo) the surface of the concrete laid on the previous day should be washed perfectly clean, and then coated with a thin layer of either cream of neat cement, or one part cement to one part sand in the form of grout, immediately before the next layer of concrete is deposited. Sometimes, instead of grouting as above, a little cement in its dry state

is sprinkled over the surface of the old concrete, just before the new layer is deposited.

In cases where the stress is mainly compressive as, for instance, in foundations, all that is necessary is to thoroughly clean and wet the surface of the old concrete before the new is superimposed.

Hard-core.—Horizontal, and also not too sloping layers of concrete, such as floors, etc., are generally founded on a layer of stones of about the size of a quarter of a brick. This layer is called “hard-core.” It is usually 6 inches thick, and should be well rammed with a heavy rammer.

Repairing old Concrete.—A broken place in a concrete surface may be repaired as follows:—

Break away the loose broken concrete; hack the surface thus exposed so as to make it very rough; sweep it clean with a stiff brush; wet it with clean water, and paint it over with neat cement grout (cream of cement and water). While the grout is still wet, fill the hole with cement mortar consisting of one part cement to two parts clean sand, ramming it well in, and smooth off the new surface with a trowel. Keep the patch wet for several days after laying.

In the case of a patch in a granolithic floor, use the same mixture to fill the hole with, as was used in the first instance for the purpose of surfacing the floor. This is usually one part cement to two parts granite chips capable of passing a $\frac{1}{4}$ -inch square mesh.

Reinforced Concrete.—In recent years reinforced concrete, *i.e.* concrete strengthened by iron or steel imbedded in it, has come into extended use. Selected from a multitude of applications, the following may be mentioned as specially appertaining to farming: fencing-posts, drinking-troughs, storage-bins, dipping-tanks, silos, concrete reservoirs, walls of buildings, weirs and dams.

Object of Reinforcement.—Concrete is strong in compression, but very weak in tension; on the other hand, wrought iron and steel are very strong in tension.

If, therefore, in any concrete structure in which tensile stresses are induced, steel or iron be imbedded so as to effectively take up these tensile stresses, we will have a very strong form of construction.

Or, stated from another point of view: the effective use of reinforced concrete, in structures subjected to tensile stresses, will result, without sacrifice of strength, in a much lighter structure than would be possible if plain concrete were the material employed.

The wrought-iron or steel reinforcement, being entirely imbedded in the concrete, is protected from corrosion. Though no reinforced concrete structure is yet old, there is every reason to believe that reinforced concrete is a very durable material.

As has already been mentioned, metal may be imbedded in concrete with the main object of preventing the formation of large contraction cracks. Such metal is sometimes spoken of as semi-reinforcement.

Types of Reinforcement.—Ordinary mild steel or wrought iron in the form of round bars can be safely used as a reinforcement. Special indented, or deformed bars can be obtained, the object of the indentations or deformations being to improve the bond between the concrete and the steel. Plain round bars are, however, quite good enough for all purposes for which reinforced concrete is likely to be used on the farm. *Expanded metal* reinforcement is made by taking sheet steel, and perforating it all over with slits in such a way that, on the plate being expanded by a pull at right angles to the slits, a diamond mesh-work is the result. *Wire mesh* reinforcement is a woven wire fabric, which generally consists of a series of parallel main wires, connected by thinner wires woven around them, the whole forming a very open-meshed fabric. This type of reinforcement should be inserted in the concrete so that the main wires lie parallel to the direction of greatest stress (see Fig. 117).

Care should be taken to insert reinforcement in the exact position specified, or shown on the drawings. In using separate bars for reinforcing, attention must be paid to having the rods properly held, so that they may not be displaced while the concrete is being joggled and rammed into place.

When bars are used for reinforcing, they are generally inserted in two systems of bars, which cross each other at right angles. Thus we may have one system of horizontal bars and another of vertical bars. The horizontal bars should be lashed to the vertical bars, where they cross the latter, by soft tying wire.

Since bars of unlimited length cannot be obtained commercially, it often becomes necessary to splice two or more bars together. Such bars may simply be overlapped. The extent of overlap should be not less than fifty times the diameter of the bars, and the join should be securely bound by soft tying wire. If the ends of the bars be turned over to form anchors in the concrete (Fig. 175) an overlap equal to 25 diameters will suffice.

Heavy Barbed Wire is frequently used as a reinforcement. It has the disadvantage of being awkward to handle. To be effective it must be kept stretched straight while being imbedded.

FIG. 117.—Triangle mesh wire concrete pipe, as made by the Reinforced Concrete Pipe Co.

The broken stone used for reinforced concrete should be small, so that it will pack closely around the reinforcement. As already mentioned, it should be capable of passing a $\frac{3}{4}$ -inch ring, or at most, for heavier work, a 1-inch ring.

Concrete for reinforced work should be mixed rather wet, so that it may flow easily round the reinforcing steel.

As a simple example of reinforced concrete work, the process of making reinforced concrete fencing posts is described. Chapters XX., XXI., and XXII. deal with more advanced reinforced concrete structures.

Reinforced Concrete Fencing Posts.—Fencing posts of reinforced concrete are now largely used. They are strong and very durable. They may be made 5 inches square at the bottom, tapering to 3 inches square at the top, reinforced with a length of number 8 plain fencing wire in each of the four corners of the post.

Should specially strong posts be required, they might be made 5 inches square at the bottom tapering to 5" by 3" at the top, with the same reinforcement as that mentioned above for the lighter posts.

These posts should be at least 7 feet long.

The form, or mould (Fig. 118), should be strong and well cramped together, so that the boards are prevented from bulging outwards when

FIG. 118.

the concrete is filled into the form. The inside surfaces of the boards composing the form should be planed smooth, and oiled or greased. Holes, to receive the fencing wires when the fence is erected, may be formed in the posts by round wooden pegs passed through holes bored in the sides of the form. These pegs may be about 9 inches long, and $\frac{1}{2}$ inch diameter at one end tapering to $\frac{3}{8}$ inch diameter at the other end. They should be oiled or greased slightly, to insure their easy withdrawal from the concrete, when the latter has set sufficiently.

Each length of reinforcing wire should be bent over at the ends to an extent of about 1 inch, so as to anchor the wire in the concrete.

In moulding the posts, make sure first of all that the mould lies so that its top edges are horizontal. Next, put a layer of concrete, about $\frac{3}{4}$ inch thick, in the bottom of the mould, working it well into the corners. Then lay in two reinforcing wires keeping each about $\frac{3}{4}$ inch in from the sides of the mould. Put in the round pegs to form

the holes, in the post, that are to receive the fencing wires when the fence is erected. Fill in concrete to within about $\frac{7}{8}$ inch off the top of the mould, and lay in the remaining two reinforcing wires, each about $\frac{3}{4}$ inch in from the sides of the form. Finally, completely fill the form, and smooth off the concrete, level with its upper edges. The concrete, as it is filled into the form, should be well worked around the reinforcement and pegs, and into corners.

By proceeding as above directed, no iron will be nearer the surface of the concrete than $\frac{3}{4}$ inch.

Gate posts may be made 6 inches square by 8 feet long, each reinforced with four $\frac{3}{8}$ -inch iron rods. The gudgeons, on which the gate is to be hung, may be inserted in the posts while they are being moulded, or holes may be left for them in the same way as was done for the fencing wires in the case of ordinary fencing posts.

If the sand is clean and coarse, concrete in the proportions 1 : 2 : 3 will be rich enough. The broken stone should be small enough to pass a $\frac{3}{4}$ -inch mesh.

Reinforced Concrete Fencing.—The following notes on reinforced concrete fencing may be of interest.

CONCRETE FENCE POSTS.

Fig. 119 shows a mould in which six of these posts are cast at one time, but a mould may of course be used to cast one post only.

FIG. 119.—Mould for posts.

Fig. 120 shows detail of post (Type "A"), and Fig. 123 the finished post. Concrete fence posts offer great advantages over either timber or iron posts. The first cost is little more than that of timber and much less than that of iron, the upkeep is *nil*, they are not subject to

Details of post and rail fencing.

FIG. 120.

TYPE "F" for use as post for Rail Fence, Type "E".

Details of wire fence post.

decay, but withstand the effects of water, frost, and fire, and hence are practically everlasting.

Concrete fence posts may be made in any of the usual types, and, as their strength does not diminish, but rather increases with age, it is not usually necessary for them to be of the same dimensions as new wooden posts, for the latter are, as a rule, much stronger than is really necessary in order to allow for decay below ground.

Moulding Concrete Fence Posts.—About $1\frac{1}{2}$ inches of concrete, composed of 1 part cement, 2 parts sand, 3 parts coarse material broken to pass a $\frac{3}{4}$ -inch sieve and retained on a $\frac{1}{4}$ -inch sieve, should be spread evenly over the bottom of the mould and carefully tamped so as to produce a thickness of about 1 inch. On top of this layer two reinforcing rods are placed about $\frac{3}{4}$ inch from the sides of the mould, and pressed in until about $\frac{3}{4}$ inch off the bottom. Concrete is then filled and tamped in thin layers to the level of the other reinforcements. These reinforcements having been deposited, the remaining $\frac{3}{4}$ inch of concrete is tamped and levelled off.

There is a tendency for the rods to get out of place, and it is therefore preferable to make some small links to hold them together in their proper position. These, in turn, can be strung from the top of the mould, which may be removed after most of the concrete has been put in position.

The concrete should be most carefully tamped into the moulds by poking it with a small bar or paddle-shaped piece of timber, so as to make it quite dense and to force into every corner and interstice of the mould and between the steel rods. If care be given to this part of the work the posts will have a good surface, free from any cavities—often referred to as honey-combing—and the posts will be much more efficient.

Fig. 120 also shows the construction of a post and rail fence (Type "E"), the finished form being shown in Fig. 121, while the mould for making such posts is shown in Fig. 122. In this type of fencing, rails or bars are inserted in holes left in the posts. The rails are kept in place by concrete wedges fixed by cement mortar. The posts shown in the illustration measure 6" by 4" by 7' long, while the rails measure 4" by 2" by 6' long. The reinforcement in both cases consists of $\frac{1}{4}$ -inch diameter round rods of steel. Such posts may also be employed to hold the shift rails, which are in many places used in place of gates. Where

for any reason it may be considered undesirable to use concrete rails, the posts may advantageously be used in conjunction with timber rails.

FIG. 121.—Post and rail fence.

FIG. 122.—Mould for post and rail fence, closed and open.

Reinforced concrete straining and gateposts should be used in connection with the wire fencing previously described, though they

require to be made somewhat heavier than the line posts. Fig. 124 shows a type of gatepost that has been employed in practice, while Fig. 125 shows details of both straining and gateposts, and Fig. 126 illustrates their use. In this case the gates were set back from the line of the fence in order that ample room might be allowed for turning, as the roadway at this point was narrow. It will be seen

FIG. 123.—Concrete fence posts.

FIG. 124.—Gatepost with struts.

from Fig. 125 that the gatepost is 7 inches square at the base and 5 inches square at the top. The reinforcement consists of four $\frac{3}{8}$ -inch diameter round steel rods, while the struts are each reinforced with four $\frac{1}{4}$ -inch diameter rods. The earth plates against which the struts abut are made 15" by 15" by 2" thick. Similar posts, employed as corner and straining posts, may be made 6 inches square at the bottom

FIG. 125.—Details of concrete straining and gate posts.

and 4 inches square at the top, reinforced with four $\frac{1}{4}$ -inch diameter round rods. It will be seen from Fig. 125 that at a distance of about 12 inches from the top of the straining post an indent 1 inch deep has to be provided when moulding the post in order to take the end of the strut, as shown. The width of this indent must, of course, correspond with the width of the strut. Usually the indent is only required on one side of the post, but for corner and intermediate

FIG. 126.—Concrete gate and straining posts at Swanscombe, Kent.

strainers which have to be strutted on two sides two indents will be required. Gateposts also require a second indent, but in this case the indent has to be below ground level. (See Type "D," Fig. 125.)

In the case of posts for wire fencing, the holes for the wires may be formed by inserting rods (very slightly greased), horizontally, through holes in the divisions of the mould between each post. These rods are withdrawn as soon as the concrete has set sufficiently to retain its shape.

CHAPTER XIV

COW-BYRES

ONE of the most important buildings on the farm is the cow-byre.

Main Types.—Two principal types may be mentioned, viz. :—

1. The single byre.
2. The double byre.

In the former the cows are ranged in a single row, in the latter in a double row. The cost of construction per cow accommodated is less for a double than for a single byre, since, in the case of a double byre, one central passage serves both rows of cows.

Double cow-byres may be arranged as follows, with

- (a) One central combined cleaning, milking, and feeding passage, the cows standing with their heads to the side-walls as shown in Figs. 127 and 128.
- (b) One central cleaning and milking passage, and two feeding passages, one along each side-wall. The animals stand in two rows facing away from each other (see Figs. 129 and 130); or
- (c) One central feeding passage, and two cleaning and milking passages, one along each side-wall. The animals stand in two rows, head to head.

In designing a byre the following objects should be kept in view :—

1. **Cleanliness** is essential from the point of view of the health of the cows, as well as of the purity of the milk produced.

Milking and cleaning passages should not be less than 4' 6" wide for single byres, and 6 feet for double byres (*i.e.* where there is a row of cows along each side of the passage in question).

In the climate of South Africa cows can, all the year round, be taken outside for watering purposes; no elaborate system of water service to each stall is therefore necessary, though, if circumstances permit, it is probably desirable.

A service of water to one end of the byre, for cleaning purposes, is convenient if it can be arranged for.

FIG. 127.

The walls of a cow-byre should be lime-washed at least twice a year, in order to cleanse them and destroy disease germs.

2. **Ventilation and Air Space.**—Ventilation will be amply provided for if openings, extending the full length of the byre, be left between the top of each side-wall and the corrugated iron of the roof, and if the roof be left open along the ridge. The openings between the top of

FIG. 128.

each side-wall and the iron of the roof may be 3 inches wide, while the opening along the ridge of the roof may have a width of 18 inches protected by a raised, curved ridge-cap as shown in the accompanying drawings.

The doors should be hung about 1 inch clear of the floor, so that

FIG. 129.

fresh air may enter below the lower edge of each door when it is closed. Further, the doors should be hung in two halves, upper and lower, and the head of each door frame may be provided with a few louvre-boards.

FIG. 130.

All windows should be capable of being opened over their whole area. They should preferably be of the "drop-back" type, *i.e.* hinged along their lower edges in such a way as to open inwards; they will then, when open, tend to deflect the entering air upwards.

Closely connected with the subject of ventilation, is that of the cubic air-space to be allowed.

According to the size of the breed, cows should be allowed from 500 to 700 cubic feet per head, but good ventilation and good air circulation throughout the building are probably of greater importance than cubic air-space.

3. Lighting.—Sunlight is an excellent germicide, and should therefore be freely admitted, 2 or 3 square feet of lighting area being allowed as a minimum to each animal.

As mentioned under "ventilation" the windows should be made to open over their whole area in order to supplement the ventilation, especially in hot weather.

If the animals are stalled with their heads to the wall, the bottoms of the windows should be from 5 to 6 feet above the floor; if, however, a passage intervenes between the cows' heads and the wall, the windows may be a little lower.

4. Comfort and Health of Cows.—Throughout the design, the comfort and health of the cows should be kept well in view. The more comfortable a cow is kept, the better results will she give at the pail.

Very often, double cow-byres are arranged so that the animals stand facing each other on each side of a feeding passage, cleaning passages being provided down each side of the byre.

This arrangement possesses the advantage of convenience in feeding the cows with the minimum of trouble, but, on the other hand, certain objections can be urged against it.

Thus the foul air from the lungs of the animals is concentrated at the middle of the byre, and one infected animal may quickly and easily infect its neighbours.

Other objections are that the animals' heads are too far removed from the fresh-air inlets, and that there are two passages for the removal of manure to be kept clean, whereas there is only one when the animals in each row stand facing away from each other.

5. Economy of Labour.—In these days when labour is scarce and generally unsatisfactory, it is more than ever important that the work

of feeding and cleaning should be reduced to a minimum by correct internal design, and also by situating the byre in a convenient position with regard to food-stores, manure heap, etc.

In this connection may be mentioned overhead feed, litter, and manure carriers, which are now in such general use in Canada and the United States, and save an immense amount of labour.

FIG. 131.

The general arrangement of such a carrier gear is illustrated in Fig. 131. The carrier is self-emptying and, if the rail be laid with a slight slope towards the dung-stead, will run out by gravity and empty automatically by the action of the trip stop TS (which may be placed at any desired point on the line) on the trigger T, as shown in Figs. 132 and 133. After emptying, the carrier may be pulled back by means of an attached rope, the end of which has been retained in the hand.

FIG. 132.

The better types of carrier are provided with a raising and lowering

gear so that they may, when required, be lowered to the floor for purposes of filling or emptying.

FIG. 133.

Keeping in view the above objects the following points remain for consideration :—

Site.—The site will probably be determined by the disposition of the other buildings of the steading.

If possible, it should be dry and moderately high, and should be conveniently placed with regard to the other buildings, and in relation to the supply of fodder, removal of manure, etc.

The byre should also be placed so that the cattle can have easy access to the nearest pasture, without opportunities for straying or interfering with other stock.

The byre should, if possible, be sheltered from cold winds.

A site possessing a gentle slope assists drainage.

The Walls.—The walls may be of stone, brick, concrete, wood, or wood-and-iron, according to the material most cheaply available in the district concerned, and the quality of building desired. The last two are not so durable as the first three, and a wood-and-iron building is a bad heat insulator, *i.e.* is hot in summer and cold in winter.

If of stone the external walls should be 20 inches thick, and party walls, if any, from 15 to 18 inches thick, the stones being laid on their natural bed, *i.e.* with the laminations horizontal.

If of brick, the walls should be at least one brick, or 9 inches thick.

If a 9-inch external wall consists of good bricks, well laid, it should require no support from buttresses.

When, however, a 9-inch wall is built of inferior bricks, laid by partially skilled labour, it will be well to provide occasional buttresses, as shown in Fig. 129, where a buttress is built mid-way between adjacent windows, the buttresses being thus 14 feet apart from centre to centre.

If the walls have been built of good bricks, it will be sufficient to point them, both outside and inside the building, with cement mortar.

If, however, poor quality bricks have been used, the walls should be plastered both outside and inside the building. The plaster applied to the outside of the building should be cement plaster, and this material should also be applied inside to a height of at least 6 feet from the floor, on account of its superior strength to resist breakage by knocks from animals' horns, etc.

All sharp corners of doorways, etc., should be rounded off to prevent animals injuring themselves. To effect this purpose, in the case of brick buildings, bull-nosed bricks may be used for the jambs of door-ways.

The life of a wood, or wood-and-iron building will be greatly lengthened by using creosoted timber for all uprights and sills.

If animals are stalled heads to wall in an iron building, their breath condenses on, and runs down, the corrugated iron of the walls, in cold weather. This may be prevented, and the comfort and warmth of the animals increased, if the inner side of the wall be close-boarded to a height of 4' 6" above the floor. One-inch deal boards may be used for this purpose.

The Roof.—In this country, for reasons of cost, the roof covering would probably consist of corrugated iron. This material, as already mentioned, has the fault of being a bad heat-insulator. Thatching is much better in this respect, but it cannot be recommended on account of the difficulty of thoroughly disinfecting such a roof, after an outbreak of infectious disease, since it cannot be whitewashed or sprayed effectively. Further, the use of thatching appreciably increases the risk of fire, a matter of great importance when valuable animals are housed.

Various corrugated iron roofs suitable for cow-byres are illustrated and dimensioned in this chapter, while a roof suitable for any particular width of byre can also be selected from Chapter VI.

The Floor.—A perfect floor would be

(a) Impervious to moisture, and non-absorbent ;

- (b) Not too cold or damp ;
- (c) Not slippery ;
- (d) Of uniform, hard-wearing material, which will not wear into hollows ;
- (e) Easily cleaned.

No material fulfils all these conditions. The following flooring materials are used : cement-concrete, hard blue bricks, asphalte.

Good cement-concrete, well laid and finished, forms probably as good a floor as can be got, being specially satisfactory from a sanitary point of view. Such a floor may consist of 4 inches of concrete laid upon a 6-inch layer of hard-core, both hard-core and concrete being well rammed while being laid.

The concrete may have proportions of 1 : 3 : 6 if the sand is very clean and otherwise suitable (say river sand); but if the sand be even only slightly dirty or fine in the grain, proportions not leaner than 1 : 2 : 4 should be adopted.

The above 4-inch layer of concrete should be topped by a 1-inch layer of granolithic, as specified and explained on p. 133.

To prevent slipping, the surface of the floor should be indented with grooves of V section, about $\frac{3}{4}$ inch deep, and from 4 to 5 inches apart. With the same object in view the floor surface may be roughened by brushing it over with a stiff brush, before the granolithic has quite set.

Hard blue bricks, if easily obtainable, may be used for the floor. Such a floor would consist of a lower layer of hard-core, a mid layer of $2\frac{1}{2}$ inches or 3 inches of concrete, and an upper layer of the hard blue bricks, laid as explained for stables in Chapter XVII., p. 185.

It is impossible, however, to obtain bricks of uniform hardness, hence a hard blue-brick floor wears unevenly, and hollows soon form in its surface.

Ordinary bricks are quite unsuitable as a flooring material, being much too soft and absorbent.

The front part of the stalls, to a distance of about 3' 6" from the manger, may with advantage be laid with asphalte, clay, or ant-heap; this conduces to the comfort and warmth of the animals while they are lying.

If asphalte be put down it may consist of a layer $\frac{3}{8}$ -inch thick carried on 3" of concrete.

Drainage.—No covered drains should be permitted inside cow-byres.

They are more difficult to keep clean than the open variety, besides which, dirt in closed drains is out of sight which, in most cases, means "out of mind" as well.

Each of the open cow-byre manure channels should discharge into a sump *outside* the byre, such as the two sumps marked "S" in the frontispiece, from which a 6-inch stoneware drain pipe leads to the liquid manure tank, adjoining the dung-stead.

See Chapter XXV. for a description of the drainage scheme outside of the byre.

Internal Design.—The chief points that claim attention in the internal design are—

- (a) Facility in cleaning and feeding;
- (b) The reduction to a minimum of the risk of contamination of the milk produced;
- (c) The health and comfort of the animals.

Manger.—It is quite a mistake, but one which is often made, to place the bottom of the manger above the floor level. With the manger so raised the following is what happens:—

When feeding, the cow has her head over the manger, but before she can lie down she has to step back so that her head may clear the high manger. The length of the stall, from manger to manure channel, has to be made long enough to suit this second position, and is consequently too long for the first position. Any manure which the cow may drop, while she is standing in the feeding position, will fall on the place where her hind-quarters will be when she steps back and lies down. It is therefore quite impossible to keep the cows clean when the stalls are fitted with high mangers.

The great secret in building stalls, is to arrange them so that the cow lies down in the same floor space as that which she occupies while feeding. This can only be done by building the manger with its bottom at floor-level, and with its edge next the cow of such a height that she can comfortably rest her head over the manger when lying down (see Figs. 129, 130, etc.).

In the case of double stalls, the manger belonging to one cow should be divided off from that belonging to the other by a concrete cross partition, so as to form two separate feeding troughs in each double stall. The internal corners of these feeding troughs should be well rounded in to facilitate cleaning.

In some byres, the manger cross-partitions between adjacent cows consist of iron or steel plates, which can be hinged upwards out of the way so that the mangers can be brushed and swilled out from end to end of the byre. When this arrangement is adopted a hole and plug may be provided in the lowest manger, at the end, so that water which has been used in cleaning the mangers can run away into the manure sump outside the byre.

Glazed stoneware is an excellent material for mangers. In the accompanying drawings of cow-byres, the mangers are shown of cement-concrete.

Dimensions of Stalls.—The length of the stalls will vary, according to the size of cows to be accommodated, as follows:—

Jerseys and Kerrys	6' 6" to 7' 0"
Ayrshires	7' 0"
Cross-bred cows of average size . .	7' 0" to 7' 6"
Shorthorns, Fries.	7' 6" to 8' 0"

The above lengths are from outside wall of manger to side of gutter next the cows' heels, *i.e.* they include the width of the manger.

For larger sized cows each double stall should be from 7' 0" to 7' 6" wide, and for smaller cows 6' 6" wide.

If the stalls are made too short, the cows tend to stand with their hind feet in the manure channel; and if too long they drop their dung on the stall floor and, later on, lie down on it.

It is convenient to have the stalls on one side of a double cow-byre of a slightly different length from those on the other side, so that the larger cows may be stalled on one side of the byre, and the smaller cows on the other side. This arrangement is shown in Figs. 127 and 128.

The stall floors should have a fall of about 1 inch towards the manure-channel.

Stall Divisions.—Stall divisions or "travises" may be from 5' 0" to 5' 6" long by from 4' 0" to 4' 6" high for the type of stall shown in Figs. 127 and 128.

Figs. 127 and 134 illustrate a serviceable type of stall division constructed of iron tubes—old boiler tubes can sometimes be obtained for the purpose. If desired, these divisions can be made close, by screwing on to the side of each a single thickness of sheet-iron; this might be advisable for stall divisions adjoining doorways.

The part of the division over the manger might be filled in by sheet-iron, in the above way, so as to prevent cows from thrusting their heads through, in an endeavour to steal food from their neighbour's trough.

Stall divisions of this type, constructed of wood, are illustrated by Figs. 128 and 135.

The head-posts are bolted to the wall; while the heel-posts are supported by being checked into, and bolted to, hardwood feet sunk in the concrete of the floor. The heel-posts extend upwards, and are bolted

FIG. 134.

to a $4\frac{1}{2}$ " by 3" scantling running parallel to the length of the byre, and nailed to the tie beams of the roof-trusses.

The surface of the stall floors should be slightly raised around the feet of the posts, to keep water away from the timber, thus preventing rotting.

To the intermediate (hardwood) posts are bolted two $\frac{5}{8}$ -inch round iron bars, one on each side of the post, on which the ring at the end of the cow-chain can slide up and down. That part of the cow-chain which encircles the animal's neck is provided with a **T** head at one end and three rings at the other, through any one of which the **T** head can be passed, according to the circumference of the cow's neck. (See Fig. 140.)

FIG. 135.

FIG. 136.

In the type of tie shown in Fig. 137 a strap, with buckle, is used to encircle the cow's neck. This type is more expensive than the cow-chain.

FIG 137.

The bars, on which the ring at the end of the cow chain slides, in the case of a tubular division, are clearly shown in Fig. 134.

FIG. 138.

A type of stall-division which has become very popular is the reinforced concrete division. Such a division, by Young and Co., Westminster,

is illustrated by Fig. 139. The reinforcement may consist of steel or wrought-iron bars, $\frac{3}{8}$ inch in diameter, tied together with wire where they cross each other. The concrete may be 3 inches thick. Probably the easiest way to make these divisions is to mould them lying on their side, in a horizontal position. The divisions should be solidly built into the wall and floor as shown.

Instead of making the slabs solid as in Fig. 139 it might be advisable in many districts, for the sake of coolness, to ventilate them by slots

FIG. 139.

or holes, the reinforcement being arranged clear of these ventilation orifices which may easily be formed by arranging suitable blocks in the mould used to form the divisions.

Reinforced concrete divisions are very sanitary, being easily kept clean by periodic washing with water, and lime-washing.

Another method of tying cows is illustrated by Figs. 129, 130, 136, 138, 142, and 144. This method, in which the animal's neck is held between stanchions which are allowed a certain degree of freedom of swing and rotation, is much used in Canada, the United States, and

Australia. This system ensures that the cow shall lie with her head over the manger.

A byre fitted up to suit the system of tying under discussion is illustrated by Fig. 130. The mangers are shaped so as to allow of easy cleaning, and the feeding passages are raised above the general

FIG. 140.

FIG. 141.

SECTION ON "AB".

FIG. 142.

floor level to facilitate the filling of the mangers. This, however, is open to the objection of making the cows appear small to possible purchasers walking along the feed passage.

The stall fittings of this byre are largely of hardwood. Each stall division consists simply of a length of $1\frac{1}{4}$ inch wrought-iron piping, bent to suit, and having one end bedded in the concrete of the floor, and the other end passed through a hole in a 2" by 6"

SKETCH OF SPRING "S".

FIG. 143.

vertical hardwood post and fixed by means of a back-nut on each side of the post.

These posts also serve to carry two 2" by 4" hardwood rails, running the length of the byre, from which the stanchions are suspended by short lengths of chain. The stanchions are attached to the curb of the manger, at the bottom, also by short lengths of chain long enough to

allow the cow a certain amount of freedom. The stanchions are detailed in Fig. 142.

The left-hand stanchion is fixed, but that on the right can be swung back so as to admit the cow's head. The top of the swinging stanchion is cut to an inclined plane, so that when it is moved back into position to clasp the cow's neck the stirrup latch C is forced upwards. When the stanchion reaches the vertical position, the spring S forces the latch C downwards into position, thus fixing the swinging stanchion. To release the cow, the latch C must be lifted up by hand. The above stanchion was designed by the author, with a view to its being readily made by a local tradesman.

Fig. 129 shows another design of byre in which the stall fittings and neck stanchions are entirely of iron. These fittings are largely manufactured in Great Britain and America and cost, here, about £1 10s. per stall.

Fig. 144 details a type of stanchion made in Natal hardwood by Messrs. the City Timber Mills, Ltd., Pietermaritzburg, Natal, and sold by them at a very reasonable cost. The swinging stanchion is on the left. It is shown in the vertical or "closed" position. To open it the small hardwood lever at the top is raised, by means of the $\frac{3}{8}$ -inch diameter iron handle shown, when the stanchion swings back into the "open" position by its own weight. The stanchions are pivoted at top and bottom, on $\frac{5}{8}$ -inch diameter pivots, so that they can rotate freely when the cow turns her head.

The stanchions shown in Fig. 145, since they do not pivot, are suitable only for holding cows for a short space of time, *e.g.*, while they are being milked.

If the number of double stalls in the length of a byre exceeds 10 (or 20 single stalls) the provision of doors in the side walls, in addition to the usual doors in the end walls, will be found to add greatly to cleanliness and ease of working.

Doors through which cows have to pass should not be less than 4 feet wide in the clear, and may be made 7 feet high.

Manure Channels.—Manure channels should not be less than 18 inches wide, though, if the expense of building the byre wider be no object, they may with advantage be made 24 inches wide. The advantage of a wide gutter lies in the lessened likelihood of its being blocked by solid excreta, forming pools of urine into which the animals' tails are apt to hang every time they lie down.

CHAPTER XV

PLAN AND DESCRIPTION OF SANITARY DAIRY SHEDS

THE author is indebted to Mr. E. E. Downing, of Sheltered Vale, Rosetta, Natal, for permission to publish the accompanying line plan, Fig. 146, and description of sanitary dairy sheds designed by him. The drawing and description were originally published by Mr. Downing in the "South African Agriculturist and Stock Breeder."

The annexed plan is of a building comprising cow and calf sheds, silos, feed-room, engine-room, and separator-room, in one rectangular block and under one roof, in a compact and convenient form. It is designed for twenty cows and seventeen calves, but capable of extension indefinitely, by adding cow-stalls and calf-pens to the right-hand side of the plan, without interfering with the working arrangements which are all located at the left-hand side of the plan.

AA represents two rectangular silos, with corners rounded off to enable the silage to be closely packed. These silos may be filled from the outside of the building, by means of a power-driven silage cutter and blower, through an opening in the roof; or from the feed-room, by the same means, through the doors (1a) which are constructed in sections 3 feet high. These sections are made to slip in, one at a time, as the silo is being filled, or to slip out, one at a time, from the top downwards, when the ensilage is being fed.

BB is the feed-room with brackets (*a*), shafting (*b*), and pulleys (*c*), along one side to enable the power-driven machines (*d*) to be used, such as chaff-cutter, corn and cob mill, cake crusher, etc.

The shafting in the feed-room is high up and the pulleys are driven by a belt (*e*) running through openings in the walls of engine- and feed-rooms. Foodstuffs in sacks, such as bran, mealies, cake, etc., may be conveniently stored on the floor underneath the shafting, and are handy for grinding or mixing on the floor space under the overhead carrier track, whence they and the ensilage from the silos can be carried in the overhead carriers round the feeding alleys in the cow and calf sheds.

Green foods, such as kale, grown on the farm can be brought in waggons to the door of the feed-room, and there be off-loaded and carried to the cows'

Overhead track for carriers; AA, Silos; BB, Feed-room; CC, Cows; DD, Loose-boxes; EE, Calf-shed; FF, Engine-room; GG, Separator and washing-up room; H, Covered pits for liquid manure; I, Sliding doors; Ia, Silo doors; J, Swing doors; K, Swing gates (bar); L, Windows; M, Sliding panels for feeding in loose-boxes; N, Entrance for cows; O, Entrance for calves.

FIG. 146.—Ground plan of sanitary dairy sheds fitted for overhead carriers and milking machines.

mangers. By extending the carrier track a few feet beyond the doorway, the carriers could run over the waggon and be loaded from it direct.

CC, the cowshed, has stall room for 20 cows, and two loose-boxes which are useful for cows near calving. To give more room in these boxes the manger is placed close up to the wall, and a small sliding-panel door (M) above the manger is provided for feeding. The cow-stalls are in pairs, with short partitions in the middle to give room for the milking machines (○) to stand between the cows forming each pair. The vacuum pipe (V.P.) is attached to the uprights of these short partitions about 6 feet from the ground, and at these uprights there are stall cocks (f) which are connected with the milking machines (pulsators) by means of a 6-foot indiarubber hose.

The cows, which enter the shed at N, are prevented from going out at the other end of the shed by the double bar-gates KK, and are secured by the stanchions (g) with their heads over the mangers (h). The feeding alleys (PP) run in front of the cows, and are served by the overhead carriers.

The drop (or gutter) Gu at the back of the cows can be cleaned out, and the manure and litter removed in the overhead carrier running out through the entrance (N) of the cowshed; the track can be continued outside the shed and the litter-carrier can be arranged to dump its load on a waggon or manure-spreader, or on to the manure-heap. By means of adjustable switches on the carrier track the litter and manure from the calf pens can be brought round and dumped at the same place as the manure from the cowshed.

The gutters have a fall towards the entrance (N) sufficient to drain off any urine, which runs through 4-inch pipes under the floor of the alley (QQ) into covered catch-pits (HH).

On the vacuum pipe, in the stall nearest the engine-room, is the vacuum gauge (i), which should register 16 inches to obtain satisfactory results with the milking machines.

At the end of the vacuum pipe, in the stall on the opposite side of the shed, is a valve (j) adjusted to allow air into the pipe should the vacuum exceed requirements.

EE, calf-shed. This consists of 17 separate pens for calves, five feet square, each with a gate and a 3-foot manger (k) with a division of 1 foot at the gate end. This small division, one foot square, is handy for standing the milk buckets in when feeding calves, and prevents the calves upsetting the buckets. When the calves have finished drinking, the buckets can be removed, and the feed of bran and meal

put in the small division, the larger one being used for feeding the more bulky fodders, hay, etc.

The overhead carriers can, by means of the adjustable switches, be brought from the feed-room right down the centre alley of the calf-shed, handy for the mangers on either side.

The floors of the calf-pens should be of cement concrete with a sufficient fall towards the gates to allow any urine to run into gutters (*gu*) on each side of the alley, which gutters should have sufficient fall to carry the liquid manure away into the covered pits (HH) on each side of the entrance (O) to the calf-shed.

The partitions and gates of the calf-pens would be particularly sanitary if made of piping and interlaced wire like the "Cyclone" gates, but the mesh must be small enough to prevent the calves sucking or licking each other. The advantage of these gates and partitions would be that fresh air could circulate freely all round the shed.

FF, engine-room. Is arranged as follows:—Vertical boiler (*l*) and engine (*m*), water tank (*n*) for filling boiler by steam injector.

Brackets and shafting (as in feed-room), with pulleys to drive shafting in feed-room and also vacuum pump (*p*), which is connected with vacuum reservoir (*q*), overhead, by a 1-inch vacuum pipe, the reservoir being connected with the vacuum pipe running round the cowshed. In the corner of the engine-room is the coal or fuel bin (*r*), and a steam pipe (*s*) is carried (overhead) from the boiler into the separator and washing-up room to provide steam for various purposes.

GG, separator and washing-room, is fitted with steam turbine separator (*t*), steam turbine Babcock tester (*u*), wash-up trough (*v*), brine tub (*w*) for boiling rubberware, cold water tub (*x*) for keeping rubberware immersed when not in use, circular platform with steam jet in centre (*y*) for steaming cans, buckets, etc., can and bucket rack (*z*), slate-top table at window (*za*) for use in testing samples of milk or cream with Babcock tester.

The steam pipe (*s*) which is brought through the wall from the engine-room has connections with turbine separator, Babcock tester, brine tub, wash-up trough, and steam jet, each connection being fitted with a wheel valve to turn on or shut off steam independently; the main steam pipe can be $\frac{1}{2}$ inch with $\frac{3}{8}$ inch connections, or $\frac{3}{8}$ inch throughout.

For boiling water in the wash-up trough or brine tub, the steam

pipe should be carried down inside to the bottom, then an elbow should be attached and a length of piping carried along the bottom of the trough or tub nearly the full length or width. This pipe should be drilled with holes or have slits cut in it, every two inches, to allow steam to escape all along. The end of the pipe should be closed with a plug. When it is required to boil the water or brine it is only necessary to open the valve and turn on the steam.

Should it be advisable to pasteurise milk, which has to travel a long distance, this can be done by standing the cans of milk in the trough and boiling the water round the cans by means of the steam. The milk should be heated up to 150° Fahr. and then immediately cooled down to as low a temperature as possible by being run over an aerator.

At milking time the litter carrier can be run outside the shed, leaving the track clear to use a milk carrier to remove cans of milk from the cowshed to the separator room, and by an extension of the track the heated milk could be run on to the aerator-room, which should be a cool, airy room away from the main building.

There is ample room above the shed for an extensive storage loft with a chute to deliver foodstuffs into the feed-room.

CHAPTER XVI

DESIGNS FOR BULL-BOXES AND EXERCISE YARDS—SMALL BUTTER-MAKING DAIRY—SMALL CHEESE-MAKING DAIRY

Design for Bull-Box and Exercise Yard.—Fig. 147 is a perspective, sectional view of a bull-box and its adjoining exercise yard. This design of box is similar to that indicated in the plan of the steading reproduced in the frontispiece. The box and feed passage have cement concrete floors, the surface layer of which is divided into squares by V joints, to prevent irregular cracking. A "single" sliding door (see Chapter X) is fitted between box and exercise yard. The dwarf wall between feeding passage and box is protected by a coping consisting of a 9" by 3" deal, fixed by $\frac{3}{8}$ " bolts with large washers built into the brickwork. The manger is of zinc, or 22 gauge plain galvanised iron sheeting, supported by a timber framework; the cross-bar at the top prevents the bull from climbing on to the manger, with his fore-feet, and looking over into the feed passage. Ventilation is provided for by open eaves and roof ridge, the latter being shielded by a curved, raised ridge cap. The windows in the feed passage are of the drop-back type, and the door opening is carried up to the eaves, so as to admit additional light and air. The yard walls are built in Colonial or garden bond, the headers being shown shaded. The level of the exercise yard is a few inches below that of the floor of the box, and a strip of a few feet wide next the box is flagged. The remainder of the yard may be surfaced with gravel.

Small Dairy for Butter Making.—Drawings for a butter dairy are reproduced in Fig. 148.

The dairy there shown contains two apartments, viz. a working-room, and a butter-and-milk room, in addition to a stoep or verandah, all being under one roof.

The working-room, 10 feet by 18 feet in size, might contain a churn, separator, milk cooler, and butter worker, besides a few shelves on which small utensils, separator parts, etc., may be placed till required.

to the roof. Again for the sake of coolness, the eaves project about 2' 6" (measured horizontally) beyond the walls. The projecting roof shades the windows, which are built high up under the eaves.

The floors of the two apartments, and of the stoep, may be of concrete with a granolithic face. Small depressions or gutters are formed in the floors, as shown by the broken lines. These gutters carry away water, used for washing the floor, etc., on to the veld at A. The floors should slope towards the gutters, and the granolithic should be carried at least 6 inches up the walls, so as to round in the corners formed by the junction of floor and walls. This does away with square corners in which dirt could accumulate, and also protects the foot of the walls.

Both windows and doors should be fitted with fly-screens. For the sake of coolness, it is sometimes recommended that the windows be double, *i.e.* that two windows be fitted with a dead air-space between the glass of the one and that of the other. In any case windows that are exposed, at any time of day, to the sun, should be provided either with blinds of a deep blue colour inside, or else with louvred shutters outside. Windows should be situated, wherever possible, in those walls which receive least sun.

Small Dairy for Cheese Making.—Fig. 149 illustrates a small dairy for cheese making, containing a working-room, curing-room, and verandah. The construction of the building is much the same as that of the butter dairy already described, except that the walls are of stone masonry built thick, 24 inches, for the sake of coolness. Air bricks, V, are inserted in the gable walls, just below the level of the ceiling.

The curing-room is situated at the coolest side of the building, and contains shelving on which the cheeses may be laid to cure. A brine tank, which may be formed in concrete, is provided if the intention is to make Gouda cheese.

The working-room contains a few shelves, a cheese vat, cheese press, and work-table. The latter should be of very strong construction.

The stoep is provided with a wash-up sink, and shelves or racks on which buckets and other utensils may be exposed to the air and sun after having been washed.

The floors may be of concrete with granolithic face, and drained as in the butter dairy.

The thatched roof is ventilated by a louvred ventilator in each gable.

SECTION ON ABCD

FRONT ELEVATION.

SECTION.

FIG. 148.—Small dairy for butter making.

END ELEVATION.

GROUND PLAN.

FIG. 148.—Small dairy for butter making.

FIG. 149.—Small dairy for cheese making.

SECTION.

FIG. 149.—Small dairy for cheese making.

It is found to be difficult, in this country, to keep the curing-room as cool as it ought to be, viz. from 54° to 58° Fahrenheit. One method which is very effective in this respect is to build the bulk of the curing-room underground, only sufficient of the walls being above ground to allow of the insertion of narrow windows, with their length horizontal. The eaves of the curing-room project well beyond these windows, to increase the coolness of the room. If any trouble is expected due to dampness of the walls, the side thereof next the earth should be pointed deeply with 1 : 1 cement mortar, and then coated with a mixture of tar and pitch.

In a large dairy, a vertical boiler and proper hot water system is usually installed. In small dairies such as those described, however, the usual arrangement consists simply of an open boiler built in brick-work, and situated in some convenient position outside the dairy, but near at hand.

CHAPTER XVII

STABLES

STABLES should be plainly and substantially built, so as to reduce the annual cost of repairs to a reasonably low figure. The interior fittings especially, if not strongly constructed at first, will be constantly in need of repairs. It should be borne in mind that these fittings have to stand the hard conditions imposed by such a nervous, fidgety animal as the horse.

If the stable is to be built in brick, either 14-inch outer walls should be allowed, or 9-inch walls would suffice (except when there is a loft above the stable) if supported by buttresses at intervals not exceeding 9 feet, as shown in Fig. 150.

If of stone the outer walls should be not less than 18 inches thick.

Stables should be placed so that horses can gain access to them without having to cross yards occupied by stock, and the implement and cart shed should be conveniently situated relatively to the stable.

One or two loose-boxes adjoining, or near to the stable, are a great convenience especially in cases of foaling, sickness, etc., and to accommodate mares and foals, stallions, and horses which will never lie down in a stable.

Like cow-byres, stables may be either single or double. In the first type the horses are arranged in a single row, with their heads to one of the side-walls, and with a passage behind them for cleaning and feeding.

In the double stable, which is the more economical type when a considerable number of horses have to be accommodated, the horses are arranged in two rows—heads to side-walls—with a cleaning and feeding passage between the rows.

A forage or chaff store should be provided. It is generally situated at one end of the stable so as to be as near-by as possible. In the plan of a steading shown in the frontispiece, it will be noticed that the chaff

store is so situated that it serves the bull-boxes and cow-byre as well as the stable.

In the plans of stables reproduced in this book, a harness-room is shown. It should be fitted with pegs and brackets on which harness

may be hung, and also with a shelf for the reception of miscellaneous articles. A lock-up cupboard, in which simple pharmaceutical remedies may be stored, is also a useful adjunct.

A bin or chest for storing corn, oats, mealie-meal, etc., is almost indispensable. It should be mouse-proof, and, with that end in view, is

generally either constructed of, or lined with, galvanised iron. It should be divided into several compartments, in which the different grains can be stored.

Should it be desired to dispense with a harness-room, the width of the stable should be sufficient to allow of the harness being hung on pegs or brackets attached to the wall at the rear of the stalls. It should be pointed out, however, that harness kept in the stable itself deteriorates faster than if it were kept in a separate room, on account of the deleterious action of the stable gases, the chief offender being ammonia gas which rises from the manure deposited on the floor. In order to exclude these gases as far as possible from the harness-room, any partition separating that room from the stable should be carried right up to the ceiling, or to the roof if there be no ceiling.

Lofts over Stables.—In Great Britain it is common practice to store forage, chiefly hay, in a loft above the stable. This practice has been condemned as interfering with the ventilation of the stable. If, however, air-shafts be provided extending from the stable ceiling, through the loft, to slatted or louvred cupolas on the ridge of the roof; and if the ceiling of the stable be made high, and sufficient apertures be left in the walls just below it, no valid objections can be made to lofts on the score of their interfering with the ventilation of the stable. One air-shaft about 20 inches square should be provided for every two horses. Air-shafts are usually constructed of wood, and should be zinc-lined; they should open above the passage-way, not above the horses. A board should be fixed about 6 inches below the lower end of each shaft to break up any down-cast draught which might occur.

If a loft be provided it should be entirely shut off from the stable proper, so as to prevent the forage in the loft from being reached and contaminated by the gases from the stable.

A method of feeding, which is sometimes practised when a loft is provided, is to have a hay-rack on the wall of each stall above the horse's head, the hay being supplied to the rack through a hole—in the floor of the loft—just above the rack. This method is objectionable, and three reasons why it should not be adopted are appended.

1. The gases from the stable gain access to the loft, through the holes (above the hay-racks) in the floor of the loft.
2. The horse feeds in an unnatural position. If we were stabling giraffes, which are accustomed to graze overhead on the foliage

of trees, this method of feeding would be desirable; but a horse does not feed like a giraffe.

3. The horse may suffer injury to his eyes by getting dust, seeds, etc., into them.

Lofts are common in towns, where ground space is valuable. On the farm, however, and in view of the fine climate enjoyed by this country, it seems scarcely necessary to provide such complete shelter for forage as is afforded by a loft; in this case the provision of a chaff and forage room adjoining the stable as already mentioned, with a Dutch barn or stack near at hand, forms probably the best arrangement. The Dutch barn should, of course, be conveniently situated to the cow-byre, forming a common storage place for both byre and stable.

Corrugated iron is in general use in South Africa as a roof covering. It, however, possesses the fault of being a good conductor of heat, causing the building covered by it to be unduly warm in summer and cold in winter. The presence of a loft above a stable has considerable influence in counteracting this fault, rendering the temperature of the stable more equable. In the absence of a loft, some other method of reducing the range of temperature in the stable should be employed. Thus close boarding may be nailed on top of the rafters, and a layer of felt placed between it and the iron roof-covering. This does not reduce the cubic air capacity of the stable by such an amount as would be done by the provision of a ceiling.

The roof should be high so as to remove the corrugated iron from close proximity to the animals. This is especially necessary if the use of heat insulation, such as the close-boarding and felt mentioned, be dispensed with. If the iron is too close to them, the horses are alternately overheated and chilled. A double-slope roof is better than a flat one in this respect, and (assuming there is no loft or ceiling) it also cheaply provides a large cubic air-space per horse.

Doors, etc.—Doors of loose-boxes and stables should open to the outside. This ensures a ready egress for the horses in case of fire, and is convenient when boxes are being cleaned out.

Stable doors should not be less than 4 feet wide, and 7 feet high in the clear, though a height of 7' 6" is preferable. They may be constructed as described in Chapter X. (Fig. 99), with upper and lower portions, which can be opened and closed independently of each other.

The edges of the jambs of the doorway should be well rounded, bull-nosed bricks being used for the purpose. Similarly the edges of posts inside the stable, and all corners against which the animals might injure themselves, should be rounded off.

Cubic Air Space.—The cubic air space allowed should not be so small that, in order to keep the stable sweet, the passage of so much air through it will require to be arranged for as will render it cold and draughty. The cubic air space per horse should preferably not be less than 1200, and certainly not less than 1000 cubic feet.

Lighting and Ventilation.—It is scarcely possible to err on the side of too much light so long as direct sunlight, or the glare from white surfaces, does not impinge on the horses' eyes.

In all stables *through* ventilation should be arranged for, *i.e.* there should be windows in *each* of the two side-walls which run along the length of the stable. The best arrangement is to have a window over the head of each horse, *i.e.* at the head of each stall. These windows should be of the drop-back type, and might be of the six-light size, 23½" by 45", listed on page 103. They should be built in immediately below the wall-plate, so that the lower edge of each window sash is not less than 7' 6" above the floor of the stall to which it belongs.

In order to provide an exit for foul air, the ridge of the roof should be open. Rain, etc., may be excluded from the opening by means of a raised, curved ridge-capping as shown in Fig. 150A.

In the case of a double stable, windows as described above will of course be provided along both side-walls, since there are stalls along each side of the stable. These windows, together with the open roof-ridge and the spaces below the doors, the lower edge of which should be about 1 inch clear of the door-sill, will provide sufficient ventilation as well as light, even when the doors are closed

FIG. 150A.

The above remarks will be rendered clearer by reference to Figs. 150 and 150A, which illustrate the construction of a "single" stable. A drop-back window is provided at the head of each stall, and in the opposite wall is the door and also another window, of the sliding-sash type. The door is hung 1 inch clear of the floor so as to allow of the ingress of fresh air below it. It will be seen that these arrangements provide for good *through* ventilation and at the same time admit plenty of light, while the open roof-ridge allows of the easy escape of the heated foul air which naturally rises to the peak of the roof.

Stable Floors.—Material suitable for a good floor should be watertight, non-absorbent, easily cleaned, durable, and not slippery. No material is perfectly satisfactory in all these respects.

Slope of Stall Floors.—Horses stand most comfortably on a level surface, therefore the stall floors should be given no more slope than is absolutely necessary for drainage purposes.

In high-class stables the stall floor is made to slope from all four sides towards the centre, whence the urine is drained away in a channel covered by perforated wrought-iron plates, which can be removed temporarily in order to allow of the channel being flushed and swept out. In a stall of this type the horse stands practically on the level, but the construction is costly, and, moreover, the covering of the urine channels, even although the cover plates are perforated, is an objectionable feature.

In ordinary farm stables it is usual to slope the floor in one direction only, viz. from the mangers towards an open channel (at the horses' heels) which runs along the length of the stable. This slope should be as gentle as possible, having regard to the proper run-off of the urine. For blue-brick floors, a slope of 1 in 48, or 1 inch in 4 feet, will be sufficient to effect this purpose; while for a granolithic floor considerably less slope will suffice.

The urine channels, at the horses' heels, need not be very large. They generally take the form of shallow depressions (see cross section of stable, Fig. 150A) in the floor, about 12 inches wide and a few inches deep. They should be given a slope of not less than 1 inch in 7 feet, which, of course, will cause the depth to vary, from very little to a considerable amount at the outlet from the stable. In long stables undue depth of the urine channels may be avoided

by making them fall from each end, to mid-length, of the stable. All urine channels should be open, no underground pipes being permissible inside the stable itself.

Drainage.—In the stable shown (Figs. 150 and 150A) the urine is led from the building to a covered concrete sump outside by means of a 4-inch stoneware drain-pipe. The urine and washings may be baled out of the sump at intervals, and thrown on the manure heap; or, more conveniently, the stable may be connected with the drainage piping, leading from the cow-byre to the liquid manure tank which adjoins the dung-stead. The instructions with regard to laying the drain-pipes, given in Chapter XXV., apply here also.

Brick Floors.—Bricks are frequently used for stable floors. They are laid on a sub-layer of concrete which, in turn, rests on 6 inches of hard-core.

Ordinary bricks laid on their edges are often employed, *hard burned blues* being selected for the purpose. Even these, however, are too soft and, partially on account of their being of unequal hardness, soon wear into hollows. They are also too absorbent to be sanitary.

Specially made "clinkers" of South African manufacture are obtainable. They have their edges chamfered, and their surfaces grooved, to prevent slipping. They form a harder wearing, less absorbent floor than do ordinary hard blues.

The sub-layer of concrete on which the bricks are laid should be 3 or 4 inches thick, and a 1 : 2 : 4 mixture may be adopted.

Each brick, in being laid, should be bedded down solidly on a little cement mortar placed on top of the concrete sub-layer, and finally the joints between the bricks should be thoroughly grouted in with 1 : 2 cement mortar.

Concrete Granolithic Floor.—A good floor can be obtained by the use of concrete granolithic, *i.e.* concrete with a granolithic top. The concrete (1 : 2 : 4 mixture) is deposited on a 6-inch layer of well-rammed hard-core, and should be about 4 inches thick. While still "green," the concrete is topped by a 1-inch layer of granolithic as explained on page 133. In order to prevent slipping the surfaces of passages may be cut into 6-inch squares by $\frac{3}{4}$ -inch deep V grooves, while the floor should be finished without a glaze.

Cobble Floor.—The ordinary cobble floor, made of water-worn

stones which are usually egg-shaped and from 7 to 9 inches long, is laid as follows:—

- (1) On top of the rammed and prepared ground, put down a layer of fine sand a few inches thick.
- (2) Set each stone end up, and hammer it well down into the sand, to such an extent that its upper end comes into line with the general surface of the finished floor.
- (3) Fill in the joints between the stones with 1 : 3 cement grout for three-quarters of the distance up, then fill in the remaining distance with 1 : 2 cement grout. Finish off by sweeping over the floor with a stiff brush while the grout is still soft, so as to cause the ends of the cobbles to project slightly above the cement grout.

Flag-stone Floor.—Flag-stones are sometimes employed. They may be laid as follows:—

- (1) Put down a layer of hard-core 6 inches thick, fill in the interstices with small stones and sand, and smooth off to grade.
- (2) Bed down each flag solidly on a layer of 1 : 4 cement mortar, and grout between the flags with 1 : 2 cement grout.

In all the above cases if, after excavating the site for the floor in question, the ground be found at all soft it should be well rammed preparatory to putting down the floor.

Internal Dimensions.—The following internal dimensions are recommended:—

Single Stables for large Work-horses—

From wall in front of horses' heads to urine channel .	10' 6"
Width of urine channel	1' 0"
Width of passage	5' 6"
Total width of stable	17' 0"
Width of stalls	6' 0"

Single Stables for Cape-cart and Carriage horses.—

From wall in front of horses' heads to urine channel .	9' 6"
Width of urine channel	1' 0"
Width of passage	5' 6"
Total width of stable	16' 0"
Width of stalls	5' 6"

The above width of passage is sufficient to allow of the harness being hung on brackets or pegs on the wall.

In the case of double stables the stalls and urine channels would have the dimensions stated above, with a passage 8 feet wide between the urine channels.

Stall Divisions.—Stall divisions may be constructed as shown in Fig. 151. The $4\frac{1}{2}$ " by 3" head post is bolted to the wall by two half-inch bolts. These bolts have sunk heads, and large washers or plates on the outer side of the wall.

FIG. 151.

The 6" by 3" heel-post is sunk into the concrete of the floor, while its upper end is bolted to a 3" by 3" rail, which runs along the whole length of the stable and is nailed to the tie-beams of the roof. As shown, the concrete at the foot of this post is raised slightly above the general level of the floor, so as to keep the foot of the post dry.

The division consists of 9" by $1\frac{1}{2}$ " boards fitted into grooves in the $4\frac{1}{2}$ " by 3" top and bottom rails, which are tenoned into the head and heel posts. The division is strengthened by two 9" by $1\frac{1}{2}$ " boards nailed in a horizontal position one on each side, at about mid-height of the division. The lower rail, in order to keep it dry

and also to allow for circulation of air below the divisions, is situated a few inches clear of the floor. That half of the top rail which is nearest the head-post, should be clad with sheet zinc to prevent the horses from chewing the wood.

Loose-boxes in the Stable itself.—Sometimes loose-boxes are erected in the stable itself, the usual arrangement being to have a number of stalls with one or two loose-boxes in addition. Such loose-boxes may be made to occupy the space which would be required for two stalls.

The partitions and door for a loose-box of this type might be constructed with posts, rails, and close-boarding in a similar manner to the stall divisions which have just been described. The close-boarding should, however, extend only 4' 6" above the floor. Above this height $\frac{3}{8}$ -inch iron rods, set vertically and about 4 inches apart from centre to centre, should be arranged between the upper rail of the lower close-boarded part and another rail at a height of 7 feet above the floor. This iron railing at the top allows of the animals being seen without the attendant having to enter the loose-box, and also permits of freer air circulation.

Detached Loose-boxes.—Loose-boxes in the stable itself, such as those mentioned above, are no substitute for detached loose-boxes which can be used for the accommodation of stallions, sick animals, etc. Detached loose-boxes allow of greater quietness and purer air than can be had in the stable itself, features of advantage in the case of sick animals. Sick-boxes should be entirely shut off from the general stable, so that cases of infectious disease can be isolated; thus any party wall separating a sick-box from, for instance, the general stable, should extend right to the roof and should have no openings in it.

The loose-box shown in Fig. 150 and the frontispiece is designed so that it can be altered at will into a small stable containing two stalls. This is done by erecting the stall division shown in Fig. 152. The lower end of the heel-post is circular in cross section, and fits into a short length of 5-inch iron pipe bedded in the floor; the upper end is bolted to a $4\frac{1}{2}$ " by 3" rail nailed to the tie-beams of the roof. The head-post is bolted to the wall in the usual way and is a fixture. The division consists of 9" by $1\frac{1}{2}$ " boards, placed horizontally with their ends in grooves cut in the head and heel posts respectively. This division can be erected in a few minutes. When it is taken down a

wooden plug, kept for the purpose, should be inserted in the 5-inch pipe in the floor, so as to exclude dirt from the pipe and to prevent the horses injuring themselves by putting a foot into it.

It is often stated that 12' by 12' is large enough for a sick-box. This corresponds to a floor area of 144 square feet. A larger area, however, say 200 square feet, will be found an advantage especially when the box is used for foaling mares.

FIG. 152.

When the walls of loose-boxes are of brick or stone, their lower portion should be protected by a lining of boards extending to a height of at least 4' 6" above the floor.

This is illustrated by Fig. 153A, which shows the wall forming one side of a stall at the end of a stable so protected: The boards are 9" by 11½" tongued and grooved. They are set vertically and nailed to two 3" by 1½" wall-plates. These wall-plates are built into the wall in the usual way; they are held by strips of hoop iron nailed to them and having their ends built into the joints of the brick-work. In addition each fourth board is bolted through the wall by two ¾-inch bolts. The top of the boarding is finished off by a strip of hardwood.

The upper rails of mangers, and also the middle post shown in Figs. 153A and 154 should be armoured with zinc sheeting to prevent horses from chewing the wood. It will be found that, if these parts

FIG. 153A.

are made of the indigenous yellow-wood of the coast forests, horses will not chew them, and zinc covering becomes unnecessary.

Iron, and also glazed stone-ware mangers can be had. They are, however, too expensive for the ordinary farmer and need not be further discussed here.

Provision of Mosquito Netting.—It does not cost much to screen ventilation openings, windows, and doors with mosquito gauze. Screening is especially necessary in districts where horse sickness is

FIG. 154.

rife. Sick-boxes should be screened to exclude flies as well as mosquitoes.

In America it is common practice in summer to remove the upper section of doors, and replace it with a mosquito netting screen hung on the same hinge-hooks as those on which the door section was supported.

CHAPTER XVIII

PIGGERIES

PIGGERIES may be arranged according to either of two systems :

- (a) the centralised system,
- (b) the colony system.

CENTRALISED OR LARGE HOUSE SYSTEM

In this system the pigs are housed compactly in a series of pens under one roof, an open-air run being attached to each pen. The pens are generally arranged in one or two rows, with a feed passage (see Figs. 155A and 156A respectively).

This system is very convenient, and makes the work of attendance, feeding, and cleaning very light: on the other hand, the cost of erecting such a piggery, of a substantial nature, is comparatively high.

The frame-work for a piggery of wood and corrugated iron, built as a lean-to to another building, is illustrated by Fig. 88, and has already been described in Chapter IX.

REQUIREMENTS FOR A GOOD PIGGERY

The principal requirements to be kept in view when designing a piggery are:—Light, ventilation, dry floors, cleanliness, and avoidance of extremes of temperature. The covered pens, food preparation room, and passage should preferably be all under one roof, in order to economise labour.

Light.—Animals thrive all the better when they have plenty of sunlight. Good lighting is desirable, even though it be only to show up dirt more clearly. In designs 1 and 2 (*vide* Figs. 155A, B, and 156A, B), the general lighting of the pens and passages will be good without windows, but the

SECTION ON A.B.

DESIGN No. 1.

FIG. 155A.—Small brick piggery.

provision of one or two windows in the passage wall in design 1, and in the side walls in design 2, would probably be advantageous. They should be capable of being opened wholly or partially in order to supplement the ventilation in hot weather. A window hinged along its lower edge, and opening inwards, tends to deflect the cold incoming air upwards.

Ventilation.—In design No. 1, ventilation is provided for by leaving openings along the eaves, *i.e.* openings between the tops of the side walls and the corrugated iron of the roof.

In design No. 2, the eaves are similarly open, and in addition the roof is open right along the ridge, this opening being protected by a raised ridge-cap of curved form.

FIG. 155B.—Small brick piggy.

Dry Floors.—The difference between dry and wet floors is the difference between healthy and sickly pigs. In addition to being formed of materials impervious to moisture, the floor should be well and truly laid so that water, etc., cannot collect in pools. The floor should have a good slope towards the sewage outlets. A floor made of permeable materials, such, for example, as an earthen floor, or one of wooden spars, becomes soaked with urine and more or less insanitary and damp. This may contribute towards causing the pigs to suffer from rheumatism, and parasitic diseases such as worms. It must be remembered that the conditions of pig-life in a pen are not akin to those obtaining in open paddocks.

Cleanliness.—Pigs repay the trouble expended in keeping their sties clean. Further, pigs will second efforts to keep them clean by themselves developing cleanly habits.

No feeding-troughs should be tolerated in the sleeping pens; they

should be confined to the yards. The interior of the whole building should be limewashed at least twice a year, and the pens should at frequent intervals be washed out with Jeyes' fluid or a suitable dip to keep fleas, lice, etc., under control.

Avoidance of extremes of temperature.—This depends largely on the materials of construction employed. A good building from this point of view would be one with walls of brick or stone and a thatched roof, though a roof of this description somewhat increases risk of fire, and may harbour insects. Galvanised iron is a bad heat insulator, being too hot in summer and too cold in winter. If a galvanised iron roof be used, it should not be placed too low, as a low iron roof exaggerates the effects of extremes of temperature.

DESIGN No. 2.

FIG. 156B.—Large brick piggery.

Space Required.—A space of from 80 to 100 square feet should be allowed in a covered pen for a sow and litter, or for about six young pigs. The open yard in connection with the pen should be about half as large again. In the designs given (1 and 2) the pens with the large open yards at the food-room end of the buildings may be used for a larger number of fattening pigs.

The Site.—A naturally dry, gently sloping site should preferably be chosen for the piggery.

The Walls.—The walls should be built preferably of brick or stone; corrugated iron is too hot in summer and too cold in winter. In design No. 1 the walls are 9-inch, and in design No. 2, 9-inch and 14-inch brick walls. If of stone, the principal walls may be made 18 inches thick, and the partition walls 15 inches thick. They may, for the sake of cheapness, be built of sun-dried bricks, in which case they had better be a brick and a half, or 14 inches thick, and should be protected on their inside surfaces from the grubbing habits of the pigs. This protection

is secured by building in two horizontal wooden wall-plates, $4\frac{1}{2}$ inches by 3 inches in cross section, to which are nailed corrugated iron sheets reaching to at least 3 feet above the floor. Walls made of sun-dried bricks may be protected from rain and damp by a coat of tar applied cold. The tar will probably blister in some places. Such blisters should be scraped off and the places carefully re-tarred.

The partition walls between the sleeping pens and exercise yards should be from 3 feet 6 inches to 4 feet in height.

Partition and yard walls strongly and stiffly built of wood and corrugated iron are fairly satisfactory. The posts below ground should be charred, and they should be tarred all over, to increase their resistance to rot.

If they can be procured cheaply, old railway sleepers placed vertically with their ends in the ground make good partition walls, or these walls may be made of rough timber when it is cheaply procurable.

Foundations.—The foundations in the designs given are of masonry, of an average depth (for ordinary ground) in design No. 1 of 12 inches, and in design No. 2 of 18 inches below the surface. The stones required will probably be procurable on the farm; they should be of large size; cement mortar should be used for the foundations in preference to lime mortar. The stones should be laid on their natural beds with large headers at frequent intervals. The foundations should be topped by a damp-proof course, consisting of a layer of hot tar mixed with pitch and sand, or of hot asphalt, or sheet asphalt.

The Roof.—The roofs shown in designs No. 1 and No. 2 are of corrugated iron. The lean-to form shown in design No. 1 is cheap and quite satisfactory; for this roof, the rafters may be 6 inches by $1\frac{1}{2}$ inches in cross-section, or four rafters $4\frac{1}{2}$ inches by $1\frac{1}{2}$ inches in cross-section could be cut from a 9-inch by 3-inch deal, giving a roof not quite so strong as in the first case.

The 2-inch by 3-inch purlins should be nailed to the rafters on edge, *i.e.* with the 2-inch dimension next the rafter. This will make a stronger roof than nailing them with the 3-inch dimension parallel to the rafter.

A thatched roof made from grass or reeds is suitable, and maintains a more even temperature than does corrugated iron.

The Floor.—The floor is a most important part of the building. It should be hard to prevent the pigs from rooting it up, well laid so that

water, etc., will not collect in pools, impermeable to moisture, and non-slippery.

Probably the best floor is one of hard burned bricks laid in cement mortar on a 3-inch layer of concrete which, in turn, rests on a 6-inch layer of hard-core, *i.e.* broken bricks or stone.

A cheaper but satisfactory floor consists of a 4-inch layer of concrete resting on 6 inches of hard-core, the concrete consisting of one part cement, two and one-half parts clean sand, and five parts broken stone or shingle. Before the concrete has quite set, it may be floated over with one part of cement to two parts of clean sand, which should be brushed over with a coarse brush before setting to render the floor less slippery.

The floor will be most liable to crack at the corners, and should be carefully laid and made a little thicker there. The floor in the pen should be at least 2 inches higher than that in the yard, with a step down to the latter so as to insure a dry sleeping place.

The pen floor should have a slope of about 1 inch in 3 feet towards the doorway between pen and yard, and the yard should have a similar slope towards the sewage outlets leading to the gutter which runs along the front of the yards.

On farms where flag-stones are obtainable these will probably form the most economical floor. They should be well laid in cement. If laid without cement, urine and water percolate between the flags and soon render the earth below foul and soft, so that it oozes up between the flags under the weight of the pigs and is no longer able to maintain the flags level.

A floor of beaten earth is sometimes used, though it is not recommended except as a temporary expedient; such a floor should be thoroughly drained. The drainage may be effected by a French drain, consisting of a trench 3 feet deep filled with stones, passing below the middle of the yards from end to end of the piggery, and leading to the liquid manure tank.

A raised platform of open wooden spars is sometimes recommended to be placed in the pen to form a warm sleeping place, no bedding being then required. If this be used, it should be removable for cleaning purposes.

Drainage to Liquid Manure Tank.—The sewage outlets from the yards should discharge into a concrete or granolithic gutter having a slope of

not less than 1 inch in 7 feet. This gutter discharges through a grating at its lower end into a sump formed in concrete, from which a 6" drain-pipe leads to the liquid manure tank (*vide* designs Nos. 1 and 2). This drain-pipe should be as straight as possible, and should be provided with a man-hole at each bend. The slope of the drain pipe should not be less than 1 inch in 5 feet, and it should be steeper if the slope of the ground permits.

Boiler-house or Food-preparation Room.—Especially in the rearing and fattening of pigs, boiled food or food soaked in hot water is generally regarded as advantageous. At one end of the piggery there should therefore be provided a boiler-house and food-preparation room combined.

A boiler of about 80 gallons capacity will be found generally suitable for a moderate-sized piggery. In design No. 1 the chimney-shaft is built outside the building for the sake of simplicity in construction.

A good arrangement, and one which economises labour—in cases where the piggery can be erected at a lower elevation than the dairy—is to run a 1½-inch to 2-inch pipe from the dairy to a tank in the food-preparation room for the purpose of conveying by gravitation the skim milk, whey, and any waste milk from the dairy to the piggery.

Farrow Guards or Safe Guards.—These are for the purpose of protecting the young pigs from being overlain by the sow. In design No. 2 they consist of a horizontal rail with vertical supports at intervals, both rail and supports being made of 1½-inch gas-piping, the supports being joined to the rail by T-pieces and the corners being formed by elbows—1½-inch gas piping costs about 7*d.* per foot f.o.r. Johannesburg. The lower ends of the supports are built into the floor, as shown in Fig. 157.

In design No. 1 the guards consist of 3-inch by 3-inch hardwood rails, supported at intervals by wooden blocks.

The guard rail should be 9 inches clear of the floor, and the distance from the wall to the guard rail should be 9 inches clear.

Troughs, Doors, etc.—These can be bought in iron, as shown in Fig. 158. The same style of trough and gate can be made in wood, as illustrated by Fig. 159. Three 4½-inch by 3-inch posts are sunk 2 feet into the ground to form the gate posts, etc., the ends having first been charred or tarred to fortify the wood against rot. The trough has the usual hinged flap above it, so that it can be opened either to the pigs for feeding or to the attendant for cleaning purposes. It should be raised

slightly above the level of the floor and may be lined with galvanised sheet iron or zinc to prevent rotting. The trough may be soaked thoroughly in petroleum to prevent the pigs chewing the wood. Every-

FIG. 157.

thing must be very strong, and hardwood is to be preferred, at least for the vertical posts. The construction will be clear from the figure.

A second trough should be provided inside the yard for drinking

FIG. 158.

purposes, so constructed as not to be easily upset. Good troughs of reinforced concrete manufactured in this country can be obtained.

Cost.—For reasons of cost, design No. 1 would be more likely to be adopted than design No. 2.

A piggery to design No. 1 would cost about £160 in the Transvaal and

£120 at the coast. These prices are for four pens and yards, *i.e.* one more than shown in Figs. 155A, B. The cost may be lessened by constructing the piggery as a lean-to to another building, care being taken to leave an opening for ventilation along the upper edge of the roof. If materials

FIG. 159.

of construction, such as good clean sand for concrete and flag-stones for the floor, are obtainable near the site, the cost may be still further reduced.

COLONY SYSTEM

In this system the pigs are domiciled in separate houses, each house being situated in its own "camp." That is to say, an area of suitable grazing land would be fenced off into camps, and each camp would be provided with its own pig house.

Such isolated houses are healthy, and the animals get plenty of exercise and grazing. On the other hand, the labour entailed in attendance, cleaning, and feeding is greater than in the centralised

FIG. 160.—Portable "colony" pig house.

system, and the fencing of the camps is somewhat expensive. The amount of labour may be reduced by employing a horse and trolley to cart the slops about.

Fig. 160 details a "colony" pig house constructed of timber and measuring 8 feet by 8 feet inside, which size is suitable for gilts and small pigs. When large sows, or a number of sows, have to be accommodated suitable dimensions would be 9 feet by 10 feet.

The house shown is provided with a projecting shade on one side forming a sort of verandah, and has three sleds, on the bottom, which serve to raise it off the ground and also allow of the house being dragged to a new position when desired.

The roof is of corrugated iron.

The sides are boarded by 6" by 1" tongued and grooved boarding. This boarding should *not* be carried right up to the iron of the roof,

FIG. 161.

FIG. 162.

both under the eaves and at the ends, so as to allow of free air circulation and ventilation.

A detail drawing of the corner joints of the framework is given in Fig. 161.

The house is provided with farrow guards of 1½-inch gas piping, the lengths at right angles to each other being connected by T pieces, and the ends being fixed to the boarding of the walls by being passed through holes therein and fastened by back nuts and large washers, both outside and inside.

The floor is as illustrated by Fig. 162, and is in three parts so that it can easily be removed, through the doorway, for cleaning and airing purposes.

CHAPTER XIX

SILOS IN STONE AND BRICK

FEW events are wholly evil, and a good effect of recent droughts is the awakening to a fuller appreciation of the benefits to be derived from the making of ensilage which they have caused.

With its help the stock farmer can snap his fingers at drought, and, further, the number of head of stock which his farm can carry is no longer limited to that which can be sustained on his winter or dry season veld.

This chapter is intended to guide the farmer in the construction of a silo, and to furnish him with detailed plans for a square silo in stone or brick, this being the type most likely to be built by a farmer in this country.

The conditions essential for preserving ensilage are, according to King, "close packing in an air-tight structure when the materials have reached the right stage of maturity."

Main Types.—Silos may be classified into two principal types:—

- (a) Silos which are entirely below the surface of the ground, and which may be either unlined, or lined with brick, masonry, corrugated iron, etc.

These are closed by a layer of earth placed on top of the silage.

- (b) Silos which are mainly above the ground.

For convenience these two types will be referred to as "pit" and "tower" silos respectively.

Depth of the Silo.—The narrower and deeper a silo can be made within practicable limits the better, on account of the close packing of the silage due to the large superincumbent weight, the effects of which are:—

1. Leakage of air between the walls of the silo and the silage is less likely to occur.

2. Storage space is saved, *i.e.* a narrow, deep silo will store a greater total weight of silage than can be stored in a wider, shallower one of the same cubic capacity.
3. Less surface is exposed to the air, while the silage is being used layer by layer starting from the top, and there is therefore less chance of loss of surface silage than would be the case in a wider silo. "If the silage is fed down at a rate lower than 1·2 inches daily, moulding is likely to set in." (King.)

The height of a tower silo is limited by the power required to elevate the stuff to fill the silo, the higher the silo the greater is the power required for this purpose. A common elevator is that of the pneumatic or blower type worked in conjunction with the ensilage cutter.

The above remarks apply more to "tower" than to "pit" silos, as, on account of the difficulty of emptying them, the latter cannot conveniently be made deeper than 8 or 9 feet. Pit silos are not fed down layer by layer starting from the top, as this would expose too much surface. The method adopted is to remove the silage in vertical sections of from 4 to 6 feet wide, across the width of the pit, the superincumbent earth resting on each section having been first set aside, and each section removed to its full depth before starting on a new one. If the silage is unchaffed, a rick-knife will be required for this operation.

The Pit Silo.—The pit silo is usually made rectangular, and, as already stated, should not exceed 8 or 9 feet in depth. If the soil is stiff, it need not be lined, and it is a good plan to leave a stairway in the natural earth at one corner while excavating in order to facilitate emptying the silo.

The Tower Silo.—Tower silos are, as a rule, built partially below, but mainly above the ground. They are provided with one filling door in the roof and a number of air-tight emptying doors in a vertical row down one side. The depth of the part of the silo that is below the ground should not exceed that which conveniently allows of the lower silage being thrown out of the lowest emptying door. This limiting depth is about 6 feet from floor of silo to sill of lowest emptying door. By building as much as possible of the silo below ground, we diminish the height to which the silage must be elevated in filling the silo, and gain the advantage of a supporting earth backing to the outside of that part which is below ground.

Pressure Exerted by Ensilage on Walls of Silo.—The outward or lateral pressure of cut mealie silage when settling increases proportionately to the depth below the surface of the silage. Thus at 15 feet from the surface it is about 165 lbs. on each square foot of wall surface, while at a depth of 30 feet it is twice as much, or 330 lbs. on each square foot. For this reason the walls of silos must be very strong.

Form of Silo.—In the circular form, the materials are best disposed to resist the above outward or bursting pressure, which in this case is resisted by tensile stresses set up in the walls. This form also allows of better packing or consolidation of the silage because of the absence of corners.

Stone and brick silos are frequently built of square shape (in plan) on account of less skill being required than in the building of a round silo. Square silos also fit in better with other buildings. The interior corners of a square silo should be well rounded so as to impede settling and consolidation of the mass as little as possible.

Weight of Silage to be Stored.—In calculating the weight of silage to be stored, the usual basis is to allow 40 lbs. per cow per day, though for a mixed herd, and when other food is available, the allowance per head per day would be considerably less. Taking the figure 40 lbs., the total weight to be stored in short tons will equal the number of animals to be fed multiplied by the number of days during which they have to be fed, multiplied by 40 and divided by 2000.

Cubic Capacity of Silo.—To find the capacity in cubic feet of a rectangular pit silo, or of a square or rectangular tower silo, multiply together the length, width, and height, each expressed in feet. This neglects the slight loss of capacity due to rounding the interior corners.

Thus the silo illustrated is 14 feet square by 30 feet high, its capacity is therefore $14 \times 14 \times 30 = 5880$ cubic feet.

To find the capacity in cubic feet of a circular silo, multiply the square of the diameter in feet by the height, also in feet, and the product by 0.7854.

Total Weight of Silage Stored in a Silo.—This is found by multiplying the capacity of the silo in cubic feet by the average density or weight per cubic foot of the silage.

According to King, the average density may be taken as 36.5 lbs. per cubic foot for a silo 25 feet deep, and 39.6 lbs. per cubic foot for a silo 30 feet deep.

Thus the silo illustrated will hold $5880 \times 39.6 = 232,848$ lbs. = 116 short tons fully.

Having settled the size of the silo to be erected, the next thing which occupies our attention is the construction.

Materials of Construction.—The materials of construction most likely to come into extensive use in this country are stone, brick, and reinforced concrete. In parts of America where wood is plentiful, wood stave silos are used. These silos are circular, and are constructed of wooden staves set on a stone foundation and held together by iron hoops. The wood stave silo is open to many grave objections, most of which would probably be aggravated by the climate of this country.

All-metal silos are also manufactured, but seem open to the objection that the plates composing them are subject to the corrosive action of the silage juices.

The silo illustrated may be constructed of either stone or brick.

Part below Ground.—This (in the design illustrated) should preferably be built in cement mortar, and is best made of stonework, even though the remainder of the walls above ground are of brick. In place of using pure cement mortar, a cheaper mortar may be employed consisting of one part cement to four parts lime to fifteen parts clean sand. In the latter case, if the site is damp, the whole of the outer surface of that part below ground had better be coated with a damp-proof composition, consisting of one part tar, two parts pitch, and four resin, applied hot. The walls of the bottom portion of the silo are 27 inches thick, and are carried at least one foot above the ground in the case of the upper walls being of brick.

The silo should not be filled for at least two months after completion, in order to give the mortar in the walls time to strengthen.

Great care should be taken in building the lower part of the silo, and also the parts surrounding the emptying doors, especially the lower ones, as the walls are subjected to the greatest pressure at the base.

The excavation in the earth to receive the lower part of the silo should be made large enough to allow of thorough tamping of the earth-filling, so that it may act as a strong backing to the wall.

The Walls above Ground.—If of stone, these may be 24 inches thick at the bottom, tapering to 16 inches at the top. If of brick, the walls may be $2\frac{1}{2}$ bricks or 22 inches thick at the bottom, and $1\frac{1}{2}$ bricks or 14 inches at the top. They should be built in English bond, the bricks

SECTIONAL ELEVATION

SECTIONAL PLAN ON AA

FIG. 168.—Sectional plan and elevation of stone silo.

being laid while in a wet condition. If of stone, the walls should have large through stones or bonders every 3 or 4 feet apart, measured horizontally. Midway between each pair of bonders should be a header, *i.e.* a stone extending from the face of the wall through at least two-thirds of its thickness, the headers extending alternately from the inside face

FIG. 163A.—Elevation of stone silo, looking in direction of arrow B (Fig. 163).

and from the outside face of the wall. These bonders and headers should break line vertically.

The walls should be strengthened by building in strong hoop-iron bands at frequent intervals. The lower part of the silo, and between the emptying doors, should be specially strongly reinforced in this way. The parts weakened by the emptying doors may be further strengthened by building in long fencing standards above and below the doors.

The Roof.—The roof is shown in detail in Figs. 164 and 164A. In it the filling door is constructed, and part of it projects so as to form a roof for a chute down which the ensilage from the emptying doors passes.

The wallplates, W, $4\frac{1}{2}$ " by 3", are half-checked to each other at the corners, and are further bound together at the corners by 3" by 3" angle pieces, S.

The main principal, D, is especially strong and is put together on the ground.

The common rafters are 6" by $1\frac{1}{2}$ ", while the hip rafters, H, are 9" by $1\frac{1}{2}$ ". The hip rafters project above the ordinary rafters and carry the iron ridging for the corrugated iron roof covering.

The purlins are 3" by 2". The $4\frac{1}{2}$ " by 3" filling door frame is fixed at the bottom to an outer wallplate, T, and at the top to the 3" by 3" rafters, L, which in turn are nailed to the board, R, between the hip rafters.

In order to prevent rotting and corrosion of the roof by the gases given off by the silage while fermenting, it must be well ventilated. This is effected by leaving an opening round the eaves between the iron of the roof and the masonry of the walls, and by making the filling door of louvre form.

The space between the top of the filling door frame and the iron of the roof above it is also left open.

Another method of ventilating is to have a ventilator on the apex of the roof, leaving the aforementioned opening round the eaves.

Emptying Doors.—It is important that these should be strong, durable, and air-tight. They should preferably be made of hard wood. Fig. 165 is a detail drawing of a good type of emptying door, 2' 6" high by 2' wide.

The opening in the masonry is spanned by a concrete lintel 9 inches deep, reinforced by four $\frac{1}{2}$ -inch round iron rods.

This lintel is moulded in place, the reinforcing rods being meanwhile held in position by their ends, which pass through holes in the ends of the wooden mould.

The door frame is $4\frac{1}{2}$ " by 3" in section, and to secure air-tightness is bedded in cement mortar, a strip of hoop-iron being imbedded partly in the wood of the door frame and partly in the mortar all the way round the frame.

FIG. 164.

The door itself is constructed of grooved and tongued boards 2 inches thick by 6 inches wide, bolted to two 2" by 4" cross pieces. Its edge is bevelled, and the door frame is accurately bevelled to suit. The door is placed in position from the *inside* of the silo, and is therefore

held tightly closed by the outward pressure of the silage behind it. It is also held in place by two $\frac{3}{4}$ -inch bolts passing through the 2" by 4" bridge piece shown.

Chute.—A vertical chute down which the silage from the emptying

doors can fall is an advantage. A design for a chute is illustrated by Figs. 163, 163A, 164, and 164A. The lower end of the chute may, if desired, be fitted with a sloping bottom so as to direct the falling silage into the cart or barrow used for distributing the silage to the mangers. The design given is for a chute consisting of timber framing covered with corrugated iron. The frame is constructed of $4\frac{1}{2}$ " by 3"

FIG. 165.

timbers, and is attached to two similar timbers bolted, on the flat, to the wall of the silo by means of $\frac{1}{2}$ -inch bolts at intervals of 3 feet vertically. These bolts are built into the wall, forming two vertical rows, one on each side of the emptying doors. The sides of the chute are supported and held together by the diagonal and horizontal bolts shown (Figs. 163 and 164A).

A very convenient and labour-saving arrangement is to have the silo built close against the wall of the food preparation room, with the chute passing through the roof of the latter. The silage is then discharged direct into the feed-room.

For this arrangement the chute would require to be modified, as shown in Fig. 163, and openings, bridged by 9-inch concrete lintels, would be formed in the wall of the feed-room opposite the two lower silo emptying doors, or the wall of the silo could replace part of that of the feed-room. A ladder should be fixed up one side of the chute so that access to the silo can be gained through the emptying doors (see Fig. 163).

Floor.—If the site of the silo is dry throughout the year, a floor of beaten ant-heap laid on a 6-inch layer of hard-core (broken stone or bricks) will suffice.

Under other circumstances, the floor may consist of a 4-inch layer of concrete carried on a 6-inch layer of hard-core. If the foundation is waterlogged, the waterproof composition already mentioned may be applied not below the floor by first tamping in the hard-core with sand and applying the waterproofing to the smooth surface so formed.

Plastering.—The inside of the silo is plastered with a layer of cement plaster consisting of one part cement to one and a half or two parts clean sand trowelled as smooth as possible. The plaster is made rich and of the best quality in order to enable it to resist the destructive action of the silage juices. The smoother the surface of the plaster the better is this destructive action resisted, and also the less is the settlement and close packing of the silage retarded.

Before applying the plaster, the joints should be raked out to a depth of $\frac{3}{4}$ inch to form a key for the plaster, and the walls should be thoroughly wetted.

If inferior brick has been used for the walls, the outside of the silo may be plastered with lime or cement plaster. In the case of good bricks, it will be sufficient to rake out the joints and point with lime or cement mortar.

If the walls are of stone they should be pointed with cement mortar.

It will probably be found advisable to cement-wash the inside lining of the silo, especially the lower portion, every two or three years, in order to help to prevent softening of the plaster by the silage juices.

CHAPTER XX

SILOS OF REINFORCED CONCRETE

REINFORCED concrete forms an excellent material for the construction of silos. As an example of its use for this purpose, drawings are reproduced for a circular silo, 15 feet internal diameter by 30 feet high. The capacity of this silo is 5299 cubic feet (see p. 281). Taking the average density of the silage as 39.6 lbs. per cubic foot, which is the value given by King for a silo 30 feet in height, the silo will hold

$$5299 \times 39.6 = 209,840 \text{ lbs.} = 104 \text{ short tons fully.}$$

The wall of the silo is 5 inches thick. The reinforcement is in the form of round iron bars which are, for the most part, $\frac{3}{8}$ -inch diameter, except in the floor where $\frac{1}{4}$ -inch bars are used, and around the emptying door-ways which are strengthened by 1-inch bars.

The bars in the wall are arranged in horizontal and vertical sets, the bars (in the form of hoops) composing the former set being spaced 6 inches apart in the lower two-thirds of the silo, and 9 inches apart in the upper third. The vertical bars are forty in number, spaced at equal distances apart circumferentially. The bars of the two systems are bound together with wire where they cross each other.

The floor of the silo is 4 inches thick, reinforced with $\frac{1}{4}$ -inch diameter bars "*d*" (Fig. 167) laid crosswise so as to form a mesh-work, each mesh being a square of 12-inch side, the bars being tied together with wire where they cross each other. The ends of these $\frac{1}{4}$ -inch bars are bent around the lowest horizontal bar of the wall reinforcement.

The footing, immediately below the wall of the silo, is 12 inches thick, and, besides being strengthened by the above-described reinforcement of the floor, is further armoured by two $\frac{3}{8}$ -inch hoops connected by fifty $\frac{3}{8}$ -inch radial bars "*c*" (Fig. 167), the ends of which are bent around the hoops.

Both floor and footing rest upon 6 inches of hard-core.

FIG. 166.—Sectional plan and elevation of reinforced concrete silo.

The reinforcement of the floor and footing prevents cracking and unequal settlement.

Where a bar requires to be lengthened by splicing another length on to it, the join or splice should be made as in Fig. 175 (page 224).

FIG. 167.

With regard to the design of silos of different size from, but of the same type as, the example given, it may be stated that:—

- (1) The reinforcement and thickness of floor and footing may remain the same in average ground.
- (2) The thickness of the wall may remain the same in all silos, viz. 5 inches.

- (3) The vertical reinforcing bars in the wall may remain of the same size, the bars being spaced the same distance apart, in all silos.
- (4) If the diameter of the silo be changed, the cross-sectional area of iron in the horizontal reinforcement, per foot of height of the silo, must be changed proportionately.
- (5) In all silos of the same diameter, the same amount of horizontal reinforcement per foot of height of the silo is always necessary for sections of wall of equal distance from the top of the silo, regardless of total height.

If the silo shown be built over 30 feet in height, the horizontal reinforcing bars in the lower part of the wall (considered to be added to the silo illustrated) should be of $\frac{7}{16}$ -inch round iron bars spaced 6 inches apart. This will suffice for silos up to 40 feet in height.

Experience gained in the United States of America seems to indicate that, if silos are built higher than 40 feet, it is necessary to lead away the silage juices, expressed by the great superincumbent weight, from the bottom of the silo by means of a drain pipe. It is therefore probably inadvisable to build silos higher than 40 feet.

Emptying Doors.—These are constructed, as shown in Fig. 168, of hardwood.

The loss of strength, due to the openings for the emptying doors interrupting both the horizontal and vertical reinforcing bars, must be made up. This is effected by imbedding a 1-inch diameter bar, having the shape of an oblong frame, in the concrete surrounding each doorway, in order to strongly reinforce all four sides of the latter. To the oblong frame so imbedded, the horizontal and vertical reinforcing bars are attached by looping back, tying with wire, and bending over the end to form an anchor as shown in Fig. 168 (plan).

In order to make it possible to insert the door (as a mould) while the silo is being built, this oblong frame is not in one piece, but the top side consists of a separate bar AA with eyelets, at the ends, which slip over the vertical sides of the frame.

Ladder to Filling Door.—An iron ladder, which is detailed in Fig. 169, is provided.

It is supported on a concrete base, and is also held by lugs which are built into the wall of the silo.

In order to insert these lugs, the outer form or mould for the silo wall will have to be provided with slot holes to receive them.

FIG. 168,

FIG. 169.

FIG. 170.

In a similar way, two rows of $\frac{1}{2}$ -inch bolts running up the opposite side of the silo are imbedded to carry the emptying chute.

Sixteen $\frac{1}{2}$ -inch bolts are imbedded round the top of the silo wall, to fix the wall-plate which carries the roof.

FIG. 171.

FIG. 172.

FIG. 173.

Forms.—Full details of the forms, or moulds, are given in Figs. 171, 172, and 173.

The outer and inner forms are each constructed in four sections. Adjacent sections are connected by two 1-inch screws, so that the sections

can be drawn together, or pushed apart, as required by simply adjusting the positions of the nuts upon these screws. The moulds should be strong and rigid, and, at the same time, as light as possible. Figs. 171 and 172 give the dimensions, while Fig. 173 is a perspective view of one section of the inner mould which gives a clear idea of its construction. It will be noticed that the forms are faced with galvanised iron. This iron projects 10 inches beyond the woodwork of each sectional form, so as to bridge the space between the ends of the forms when these are in position. The galvanised iron should be greased, or oiled, just before the forms are set in position preparatory to being filled. This prevents the concrete from adhering to the iron.

The forms should be made by a skilled carpenter, as the whole work largely depends on them; in fact the erection of such a silo should be entrusted only to skilled men, it being desirable to employ a man experienced in reinforced concrete work for the concreting.

It is essential that the forms should be constructed with their cylindrical surfaces exactly at right-angles to their top face. This condition is necessary for the easy construction of a truly vertical wall.

Erection.—It is unnecessary to give a full description of the erection of the silo, as the work is similar in many respects to that involved in the erection of the reinforced concrete cattle-dipping tank dealt with in Chapter XXII, a few special points, however, require mention.

Excavation for Foundation.—As shown in the drawings, the surface of the silo floor is 5 feet below ground level. The hole excavated should be of sufficient diameter to allow of the forms, for moulding the walls, being used right from the bottom upwards. The earth should not be filled in behind the silo wall till some weeks after the part below ground has been finished, as ramming in earth behind a "green" concrete wall might injure it.

If the ground at the bottom of the excavation be at all soft, it should be well rammed before depositing the hard-core. The hard-core also should be well rammed.

Should trouble be encountered, due to water oozing into the excavation, a temporary sump may be dug at the centre, from which accumulated water may be baled at intervals. When the floor, with the exception of the part immediately over the sump, is finished, and the walls are high enough to exclude seepage water, the sump may be baled

out finally and quickly filled up, and the remaining part of the floor, over the sump, laid down.

Scaffolding.—In order to provide a means for lifting the forms, and also to support a platform for the workmen to stand on, scaffolding is required.

It may consist of eight rough poles erected at intervals round the silo, on its outer side, with their lower ends sunk into the ground. These poles are braced together, and carry horizontal beams at a level considerably higher than the top of the silo wall. From these beams four blocks and tackle are suspended, by means of which the forms may be lifted and adjusted as required.

Building the Wall.—While the floor is being laid it is advisable to form a groove in its surface, running right around it, in such a position that it is directly below the middle of the thickness of the silo wall. When the wall is built on top of this groove, the concrete of the wall enters the groove and forms a key between wall and floor which will prevent leakage between them. In fact the wall and floor are tongued and grooved together.

The building of the wall may be commenced by scribing two circles on the floor (already laid), marking the positions of the outer and inner faces of the wall respectively. The forms are then laid with their upper surface perfectly level, and their cylindrical faces up to these circles. Since the forms have been constructed with their cylindrical surfaces exactly at right angles to their top face, when the latter is set level with the aid of a spirit-level their cylindrical surfaces will be truly vertical.

After the forms have been filled, and the concrete has set hard enough to resist indentation by the thumb nail, they may be moved to a higher position. In this position the forms should overlap, and grip that part of the wall already constructed, by about 6 inches. Each time the forms are moved up, their top face must be set dead level by means of the spirit-level. This will result in the production of a truly vertical wall.

Each time the forms are set in a new position, the upper surface of the old ring, or tier of concrete, which was laid with the forms in their previous position, should be cleaned and grouted over with 1 part cement to 1 part sand, immediately before beginning to fill in the forms in their new position. If this grouting be not done, leakage of silage

juices is almost certain to occur across the junctions between the various tiers of concrete, when the silo is filled with ensilage.

It will be found inconvenient and inadvisable to work with long lengths of vertical reinforcing bar. From 6 to 8 feet is long enough for these. They should be arranged to break joint as much as possible, *i.e.* so as not to approach the condition of there being anywhere a ring of splices, formed by the joins between separate lengths of bar being all at the same level. Similarly joins in horizontal bars should be arranged to break joint vertically. The joins are detailed in Fig. 175.

The inner face of the silo wall should be surfaced by "spading" between the inner mould and the concrete, as explained on p. 135. This

results in the formation of a dense, hard face, which is resistant against the acid silage juices. Fig. 174 shows a hardwood spade for the purpose.

FIG. 174.

FIG. 175.

The emptying-doors themselves are used as moulds for the emptying-door openings. These doors will then fit quite closely in place, provided that each door has been used to mould its own opening. The edges of the door, and of any additional mould necessary, should be well oiled or greased, with the object more of filling the pores of the wood than of forming a greasy surface film.

Immediately around the doorways a rich concrete should be used which is free from broken stone, *e.g.*, a mixture of 1 part cement to 2 parts sand would be suitable.

Fig. 170, page 220, details the flange and reinforcement at the top of the silo wall. A special crown will have to be added to the forms, when in their highest position, in order to mould this part.

Patching.—Occasionally, on account of careless spading, or owing to a leak in the form having allowed the cement and sand to run away, open spaces between the stones of the concrete are found on the forms being raised. Such places should be patched *immediately* by first removing all loose stones, and, if necessary, roughing the surface to get a good bond, and then filling with a 1 to 2 cement mortar. The

patched place should be wetted every day by the application of water with a whitewash brush, to prevent its drying out more quickly than the surrounding concrete.

Painting.—The silo should be finished, both inside and outside, by the application of a coat of cement grout consisting of 1 part cement to 1 part fine sand, applied with a whitewash brush. Before applying the grout the wall should be thoroughly brushed over with a dry, stiff brush. Each part of the wall should be well wetted *immediately* before the grout is applied to that part. It is a good plan to begin painting at the top of the wall and work downwards; water running down the wall then wets and soaks into that part which has still to be painted. While the silo is being painted the grout of cement, sand, and water should be kept constantly stirred.

Spraying.—The concrete of the silo should not be allowed to become dry, for at least a fortnight after it has been deposited. It may be kept damp by spraying twice a day with water.

The silo should not be filled until at least two months have elapsed after the deposition of the last concrete.

The Roof.—The roof (see Figs. 176, 176A, 177, and 178) is octagonal in plan, and the roof covering is of corrugated iron.

During the filling of the form in its highest and last position, sixteen $\frac{1}{2}$ -inch by 15 inch bolts are set 11 inches down into the concrete, so that their ends project 4 inches above the top of the wall. The wall-plate, which consists of 6" by 3" scantlings, is held in place by these bolts. This plate is cut, fitted, and laid out, to two circles, corresponding to the internal and external diameters of the silo at the top, drawn on the ground. In this way as little as possible of the work is left to be carried out on the top of the silo.

The main principal, marked A_0A_0 in the plan, is detailed by Fig. 177, the letters on the different members corresponding to those in the elevation, Fig. 176. This principal is assembled, and put together, on the ground. It will be noticed from the drawings that the tie-beam is double, consisting of two 9" by $1\frac{1}{2}$ " scantlings nailed one on each side of the rafters.

The second principal appears in plan at B_0B_0 , at right angles to the main principal. It is in halves, one of which is detailed by Fig. 178, the letters in which figure correspond to those in the elevation, Fig. 176. The tie-beam B_2 is attached to the double tie-beam A_3 , of the main

FIG. 176.

FIG. 176A.

FIG. 177.

principal, by means of the 6" by $\frac{3}{8}$ " wrought-iron right-angle plates shown. These four plates should be securely bolted together, the bolts passing through the plates and the timber between them.

FIG. 178.

The remaining, ordinary rafters are 6" by $1\frac{1}{2}$ " in cross section, while the hip rafters are 9" by $1\frac{1}{2}$ ".

In order to allow for ventilation, and the removal of the gases of fermentation which arise from the silage when first it is put into the silo, the roof

is left open round the eaves, and is provided with a ventilator, at the peak, made of plain galvanised iron sheeting as shown. It may be advisable to net in the eaves with ordinary wire-netting, to prevent birds from nesting there.

Filling Door.—The arrangement of the filling door is much the same as that of the door already described for a stone silo, and no further description of how to erect it, and the roof which covers it, is necessary, especially if the drawings be closely studied.

Emptying Chute.—The emptying chute is the same as that already described for a stone silo, which description may be referred to.

Materials Required.—The amounts of cement, sand, and broken stone required for this silo have been worked out in Chapter XXVI; they are : 47 casks (or 94 bags) cement, $13\frac{1}{4}$ cubic yards sand, $26\frac{1}{2}$ cubic yards broken stone. 1 : 2 : 4 concrete is used.

Only the best of materials should be used. The sand should be quite clean, and should contain a large proportion of coarse grains. The broken stone should be small enough to pass a $\frac{3}{4}$ -inch mesh, and should be retained on a $\frac{1}{4}$ -inch mesh.

The amounts of other materials required can be readily estimated from the drawings.

CHAPTER XXI

DESIGN FOR RESERVOIR IN REINFORCED CONCRETE

REINFORCED CONCRETE TANK OR RESERVOIR

TANKS or reservoirs are often required on farms, for the purpose of storing considerable quantities of water, especially in the drier parts of the country. For example, such a tank, or tanks, might be required in order to store water from a pump driven by a windmill, so as to tide over windless periods. These tanks are generally built mostly above the natural ground surface, being sunk only far enough to obtain a firm foundation. No material is more suitable for the construction of such tanks than reinforced concrete which, on account of its freedom from cracking and subsequent leakage, is much superior to plain concrete for this purpose.

Drawings are reproduced in Figs. 179 to 184 for a reinforced concrete tank 30 feet square (in plan) which, when filled to a depth of 4' 6",

FIG. 179.—Perspective view of reinforced concrete tank.

will hold 25,300 gallons of water. Fig. 179 is a perspective view of the finished tank, which will render its general form clear to the reader. Each of the four walls is supported by three piers, or buttresses. Concrete of 1 : 2 : 4 proportions may be employed, the broken stone being small enough to pass a $\frac{3}{4}$ -inch square mesh, and too large to pass a $\frac{1}{4}$ -inch mesh.

barbed wires, arranged criss-cross and spaced 9 inches apart, in the middle of the thickness of the concrete. The floor is laid on 6 inches of hard-core which should be well rammed before depositing the concrete upon it. The reinforcement should be most carefully placed, exactly as indicated on the drawings. Bars should be tied together with soft wire

FIG. 181.

where they cross each other. Joins between separate lengths of bar should be arranged as in Fig. 175, the bars being given a 12-inch over-lap (wired), and having their ends bent over so as to gain a grip in the concrete. Care should be taken not to have too many joints vertically in line at any one place. Where any horizontal rod is parallel to the face of the wall, its centre-line should be $1\frac{3}{4}$ inch in from that face (either the outer or inner face, as the case may be).

The piers are broadened out at the base to a width of 12 inches, in order to increase the area with which they bear on the sub-soil.

If the foundation be other than rock or hard shale, a large, broad stone should be placed under each pier to still further increase the bearing area. The lower face of this stone should be approximately true or flat, and should be thoroughly bedded down on a layer of lime mortar, spread over the bottom of the trench dug to receive the stone.

Figs. 181 and 182 show suggested moulds or forms. These should

FIG. 182.

be rigid and, in order to prevent adherence to the concrete, their faces should be given a coat of whitewash each time they are moved upwards, preparatory to being refilled. The top of the form illustrated by Fig. 181 should be truly level when the form is set in position, so that we get a fair start with the form shown in Fig. 182. The latter form is provided

FIG. 183.—Section between piers.

with bolts. The upper row of bolts will leave holes in the concrete, which serve to receive the lower row of bolts when the form is moved up for the next fill. The bolts should be greased, so that they can be easily withdrawn from the concrete; the holes left by the bolts in the walls of the tank should be filled in, as soon as possible, with 1:2

cement mortar. Separate forms will require to be made for the piers, and firmly attached to the forms illustrated. Probably the best procedure is to have sufficient forms to reach completely round the tank, and to raise the walls horizontal layer by horizontal layer. Each layer

FIG. 184.—Section through pier.

should be completed, and left until the concrete cannot be indented by the thumb nail, before shifting up the forms for the next fill. Immediately before depositing any part of a new layer, the upper surface of the old layer below that part should be cleaned if necessary, and grouted with 1 : 1 cement grout. This will give a good bond between layers.

In order to secure water-tightness, the concrete should be put in rather slushy, and then well jogged into place. By passing a spade down between the concrete and the face of the inner form, the broken stone may be pressed back from the form, leaving a layer of 1:2 mortar on the inner face of the wall. While doing this care must be exercised not to wedge the form out of place with the spade.

The floor may be laid after the walls have been completed, the join between the floor and the lower part of the walls being formed as shown at ABC, Fig. 183, so as to prevent leakage. The barbed wires in the floor should be tightly stretched.

The walls should be protected and kept wet, for about fourteen days after completion, by hanging wet sacks over them and spraying with water twice a day. The floor may be kept covered, for a like period, with wet sacks or a layer of moist sand.

The following quantities of materials will be required :—

For the walls up to joint ABC: 55 bags cement, $7\frac{3}{4}$ cubic yards sand, $15\frac{1}{2}$ cubic yards broken stone. For the floor: 30 bags cement, 4.1 cubic yards sand, 8.2 cubic yards broken stone.

The amount of steel required can be measured up from the drawing.

Two months should be allowed to elapse, after the completion of the tank, before filling it with water. This gives the concrete time to strengthen.

The tank may be made larger in plan than shown, but, if this be done, extra piers would have to be provided, so that the piers may not be spaced further apart, nor further from the corners of the tank, than specified in the plan, Fig. 180.

CHAPTER XXII

CATTLE DIPPING TANKS

A CATTLE DIPPING TANK IN REINFORCED CONCRETE—A CATTLE DIPPING TANK IN PLAIN CONCRETE—OTHER MATERIALS OF CONSTRUCTION

Semi-reinforcement.—A structure which is reinforced simply to prevent the formation of comparatively large cracks, the reinforcement not being primarily for the purpose of taking up the tensile stresses, is said to be semi-reinforced.

The author designed and superintended the construction of a cattle dipping tank of this class on the Potchefstroom Experimental Farm.

The side-walls of this tank were made 15 inches thick at the bottom, thinning down to 9 inches at the top, and were semi-reinforced by heavy barbed wire imbedded in the concrete. In the lower half of each side-wall the barbed wires were inserted in pairs at vertical intervals of 9 inches, each wire being about 3 inches in from the front and back faces of the wall respectively. In the upper half of each side-wall one wire was inserted for every 9 inches of vertical height, being placed in the middle of the thickness of the wall. The bottom and ends of the tank were semi-reinforced by wires passing right through from end to end of the tank in the middle of the thickness of the concrete. As a result no trouble has been experienced from the formation of cracks and consequent leakage of this tank.

The only objection to the use of barbed wire as a semi-reinforcement seems to be that it is rather awkward to handle and to keep stretched during imbedment; to be effective the wire must be free from kinks or bends, and, to ensure this, should be kept stretched during the process of imbedment.

A concrete wall, if at all long, should always be reinforced parallel to its length if the formation of unsightly cracks is to be avoided.

Dipping Tank with Complete Reinforcement.—The tank, the plans for which are given here, is completely reinforced, the walls being only

A site in very clayey ground should be avoided, as nearly pure clay contracts too much in dry weather and expands again in wet weather.

The excavation should be very carefully performed, as, if too much earth be removed, much more concrete than the amount estimated will be required. The side-slopes may be formed to a wooden templet of such a shape that when one edge is set vertically, by means of a plumb-rule, the other edge gives the slope of the sides. It is better to excavate too small at first and then trim off carefully afterwards, than to run the risk of removing too much soil.

Hard-core Cushion.—Sufficient ground should be excavated to allow of a 6-inch layer of hard core (consisting of stones about the size of a third of a brick) being laid down below the floors of the swim and out-slope. Frequently stones can be picked up on the veld near the site, which, when broken across with a hammer, are about the correct size. Breaking each stone across exposes a fresh surface on which the concrete of the floor gets a good grip. The hard core should be well rammed. The race is founded on a similar layer of hard core.

Materials.—The concrete may be mixed in the proportions 1 part cement, to 2 parts clean sand, to 4 parts broken stone. The sand should be clean and large in the grain, and, to make sure of good results, river-sand ought to be used. The broken stone should be small, so as to pack closely round the reinforcement iron. It should, therefore, be capable of passing through a screen of $\frac{3}{4}$ -inch mesh.

The concrete should be mixed rather wet. If it runs off the shovel unless handled quickly, it will be of about the correct consistency. It may be mixed on a platform of wood or iron sheets. The correct proportions of sand and cement should be measured out by the use of a cask or measuring box (without top or bottom) on the platform, and should be turned over three times dry, or until the mixture assumes a uniform colour throughout.

The measured quantity of broken stone is then added.

The mixture is now wetted by water from pails, and is turned over three times wet. Care should be taken that some of the fine cement is not washed away while water is being added. Thus the mixing platform should be practically water-tight.

In turning the mixture, either dry or wet, it should be shovelled from one pile into a distinct and separate new pile, and then shovelled back again on to the site of the original pile. By proceeding in this

way we can be absolutely sure that every particle has been turned the required number of times; and we must bear in mind that reinforced concrete work requires careful supervision to see that instructions such as the above are carried out to the letter.

As concrete sets quickly, we must mix it up in small quantities as required, and deposit in position at once.

Construction.—The hard core having been deposited, put down a layer of concrete $2\frac{3}{4}$ inches thick on the bottom of the swim, and ram it well. On top of this layer the iron reinforcement is laid. First the V-shaped rods are put in position; these are $\frac{1}{2}$ inch in diameter, and the rods which form them should be bent so that the centre line of each leg is exactly 2 inches from the outer face of each wall. It may be mentioned that in all reinforced concrete work the reinforcement should be placed exactly as specified and as shown on the drawings. Here again careful supervision is required.

On top of the bottom portion of the above rods the five $\frac{3}{8}$ -inch rods which run parallel to the length of the dip are placed, being equally

FIG. 186.

spaced and tied with soft wire where they cross the $\frac{1}{2}$ -inch rods. These five rods are carried up the outslope, and also up the vertical wall at the in-end of the tank. All joints in the length of the rods should be made as shown in Fig. 186, having a 12-inch lap tied with soft wire, the ends being bent over at least 1 inch as shown, so as to anchor each rod securely in the concrete. These joints are necessary in lengths of rod longer than 12 feet, as the iron is sold in 12-foot lengths.

The rods having been carefully placed as above, the concrete surface on which they lie is brushed over with a thin layer of a mixture of 1 part cement to 1 part sand. This is called "grouting." The grout should not be applied over the whole surface at once, but only a small part should be grouted and then covered immediately with the remaining

2 $\frac{3}{4}$ inches of concrete, so as to make up the thickness of the bottom to 5 $\frac{1}{2}$ inches (the remaining $\frac{1}{2}$ inch is applied later in the form of plaster). Proceed in this way until the whole bottom has been laid.

We next set the moulds or forms for the walls in place. A suggested method is shown in Fig. 187.

The studs or posts, of 3" by 3" deal, are set 3 feet apart centre to centre, and are held in place at their upper ends by 2" by 3" cross-pieces bolted to them and also to pegs driven into the ground. The

FIG. 187.

bolts which are later on to be used for the fencing of the race may be utilised for this purpose, wooden washers being used if they are too long. The studs are held apart by horizontal pieces of 2" by 3" deal, called struts. The moulding surface itself is supplied by four flooring boards held together by cross-bars (also of flooring boards) screwed to them halfway between each adjacent pair of studs.

The forms are placed so as to mould the walls to a thickness of 5 $\frac{1}{2}$ inches. As the work proceeds, the four flooring boards are raised

all round the tank, the legs of the **V**-shaped bars being kept in place by the heavy hoop iron clips through which they pass.

The concrete is deposited in layers 9 inches thick, that being the vertical distance between adjacent horizontal $\frac{3}{8}$ -inch rods, and on top of each layer a $\frac{3}{8}$ -inch horizontal rod is laid in the position shown in the drawings, and tied with wire to the $\frac{1}{2}$ -inch rods where it crosses them, before proceeding with the next layer. These horizontal rods pass right round the tank, crossing the outslope and the vertical wall at the in-end of the tank at vertical intervals of 9 inches. The join between any two separate days' work should always be grouted with 1 to 1 grout as already explained for the bottom, and great care should be taken that all surfaces on which fresh concrete is to be laid are clean and free from earth, which is apt to fall on them from the earthen sides of the excavation.

It will be noted that only alternate **V**-shaped rods run right to the top of the walls, the others being shorter and bent over at the top to anchor them securely.

Any joints which are made should be as in Fig. 186, and the two systems of $\frac{1}{2}$ -inch and $\frac{3}{8}$ -inch rods should be tied together with wire at all points where they cross each other.

It will generally be found that the moulds can be safely moved up after allowing 24 hours for the concrete last laid to set.

The concrete is put in rather wet and should be thoroughly jogged into place with crow-bars to ensure that no blank spaces are left in the mass.

Plastering.—For plastering purposes the sand should be screened through a No. 12 sieve, that which passes through the sieve being used. The plaster consists of 1 part cement to 2 parts sand, and is applied to an average thickness of $\frac{1}{2}$ inch, making up the thickness of the walls to 6 inches. It may be finished off as smoothly as possible, except in places on which the animals have to tread, which should be rough finished by brushing over with a stiff brush while the surface is still soft. Surfaces should be thoroughly wetted before plastering them.

Capacity Scale.—The capacity of the tank at different depths has been calculated, and the results are shown in Fig. 188 in the form of a scale, which may be scribed on the side of the tank while the plaster is still soft. The dimensions 3 feet $3\frac{3}{4}$ inches up to 6 feet $\frac{3}{4}$ inch, supposed to be measured vertically, give the positions of the respective horizontal

gauge lines. The numbers on these, viz., 1500–3500 (which may be scribed on the plaster), give the capacity of the tank in gallons when filled to the mark in question. This scale will be found useful to measure the relative quantities of water and dipping fluid while the tank is being filled. See APPENDIX.

FIG. 188.

The Entering and Dripping Races.—The former is flagged to prevent dirt being carried into the tank. In the case of the tank built on this farm, it was found necessary to put iron bars across the jumping-off place to prevent slipping of the animals. Old tyre iron was used, and is most effective. These irons are indicated in Fig. 185. The parts of the irons projecting above the concrete were bored with $\frac{5}{8}$ -inch holes at 4-inch centres to allow the dipping fluid splashed up to run back to the tank. The dripping race consists of $3\frac{1}{2}$ inches of concrete founded on 6 inches of hard core, and topped by $\frac{1}{2}$ inch of 1 to 2 cement plaster, indented with grooves of triangular section about 5 inches apart from centre to centre. These grooves, which are about one inch wide at the top, run diagonally towards the gutter and help to prevent slipping. The race and gutter have a longitudinal slope of 1 inch in 7 feet, and the surface of the race has a similar cross-slope towards the gutter. The drippings which fall on the race are carried by the gutter to the sump, where solid matter settles while the fluid is returned to the tank through a 4-inch earthenware pipe.

When dipping is finished the entrance to the sump is closed by an iron plate and the rain water discharge is opened (see Fig. 185).

The entering race is 2 feet 6 inches wide between the fence rails, and the dripping race is 3 feet wide.

The fencing posts for the dripping race should be of well-seasoned hardwood and are best bedded in concrete. The best job would be

FIG. 189.

made by having the posts of sawn hardwood (say 5" by 5") bedded in concrete, with 4½" by 3" deal rails checked and bolted to them, and tarred; but if a first-class job is too expensive then rough posts and rails may be used, say gum-posts and wattle-rails, the ends of the posts which enter the ground being charred or tarred. The posts for the splash-boards may consist of 4" by 4" hardwood bedded in concrete as shown in Fig. 189. The remarks in regard to cheaper posts for the race apply equally well here.

Splash-boards or Roof-flaps.—These would be too unwieldy if made in one piece extending over the whole length of the dip. They are therefore made in sections, each side consisting of four sections, constructed of 3" by 3" deals covered with plain or flat galvanised iron of No. 24 gauge. Three of these sections will each be approximately 12 feet in length, while the remaining one will be about 6 feet 6 inches long. They are carried by hook and band hinges from the 4" by 4" posts.

On these posts, opposite which the junction between adjacent sections come, a double hinge will be required. This may consist of a double or T-shaped hook, carrying two bands, one embracing each end of the head of the T, one band being for one sectional flap, and the other for the adjoining one. The leg of the T passes through the 4" by 4" hardwood post, and is secured by a nut screwed on its end. Fig. 189 gives details of the roof-flaps, etc.

APPROXIMATE LIST OF MATERIALS REQUIRED.

Portland Cement.—Required for tank proper, 24 casks; required for dripping race and sump, 9 casks; required for bedding 40 posts, 10 casks; total cement required, 43 casks.

(The above-mentioned casks are supposed to contain 376 lbs. of cement each.)

Sand.—Required for tank proper, 7 cubic yards; required for dripping race and sump, $2\frac{1}{2}$ cubic yards; required for bedding 40 posts, 3 cubic yards.

Broken Stone.—Required for tank proper, $13\frac{1}{2}$ cubic yards; required for dripping race and sump, 5 cubic yards; required for bedding 40 posts, 6 cubic yards.

Reinforcing Iron.—1000 feet of $\frac{1}{2}$ -inch round iron; 1100 feet of $\frac{3}{8}$ -inch round iron; total weight of the above iron, 1080 lbs.

Annealed Wire.—1000 feet of $\frac{1}{16}$ inch.

Timber for Forms or Moulds.—Sides (flooring boards), 36 12-foot lengths. Studs (3" by 3" deal), 18 pieces, each 8 feet 6 inches long; 2 pieces, each 7 feet long; 2 pieces, each 6 feet long; 2 pieces, each 5 feet long; 2 pieces, each 4 feet long; 2 pieces, each 3 feet long; 2 pieces, each 2 feet long. Top cross bars ($2\frac{1}{4}$ " by 3" deal), 14 pieces, each 7 feet 6 inches long. Struts ($2\frac{1}{4}$ " by 3" deal) 15 pieces, each 4 feet long; 13 pieces, each 3 feet 6 inches long; 12 pieces, each 3 feet long; 10 pieces, each 2 feet 6 inches long; 9 pieces, each 2 feet long. Pegs, 28 pegs, each 2 feet 6 inches long.

Permanent Timber and Other Materials.—Splash-boards or roof-flaps, 2 pieces 3" by 3" deal, each 13 feet long; 4 pieces 3" by 3" deal, each 12 feet 6 inches long; 2 pieces 3" by 3" deal, each 7 feet long; 36 pieces 3" by 3" deal, each 3 feet 3 inches long; 2 pieces $4\frac{1}{2}$ " by 3" deal, each 13 feet long; 4 pieces $4\frac{1}{2}$ " by 3" deal, each 12 feet 6 inches long; 2 pieces $4\frac{1}{2}$ " by 3" deal, each 7 feet long. Plain or flat galvanised iron, 16 sheets, each 7' by 3'. Rails for race ($4\frac{1}{2}$ " by 3" deal), 36 pieces, each 17 feet long; 8 pieces, each 9 feet long. Splash-board rail (9" by $1\frac{1}{2}$ " deal), 6 pieces, each 14 feet; 2 pieces, each 7 feet 6 inches. 5" by 5" hardwood posts for race, 22 each 7 feet long, and 2 each 8 feet long (for in-end). 4" by 4" hardwood posts, for splash-board rail, 16 each 6 feet 3 inches long. 2" by

4" hardwood slip-rails, 3 each 5 feet 6 inches long. 10 18-inch hook and band hinges (with single bands). 6 18-inch hook and band hinges (with double bands). Bolts (for fencing of race), $\frac{3}{8}$ -inch diameter by $7\frac{1}{2}$ inches long, 45 lbs. Washers to suit above bolts. Nails and screws:—2 gross screws for roof-flaps, $2\frac{1}{2}$ inches long, No. 12; 1 gross screws for forms $1\frac{1}{2}$ inch long, No. 10; 3 gross screws for hoop iron guides on forms, $\frac{3}{4}$ inch long, No. 8; 7 lbs. 4-inch nails; 7 lbs. 3-inch nails. 5 2-foot lengths of earthenware pipe, 4 inches internal diameter. 10 gallons coal tar (for rails of race and splash-board rail). 100 feet heavy hoop iron.

The cost of the above-mentioned materials, exclusive of sand and broken stone, at the coast, will be about £77.

This is allowing for the purchase of jarrah posts and of deal-rails for the race. Excluding the cost of these two items, the total is about £55. The first cost may be further reduced if the farmer is content with flag-stones for the race.

For the higher price, materials for a first-class job may be purchased.

Cattle Dipping Tank in Plain Concrete.—Fig. 190 illustrates a dipping tank, in plain concrete, the internal dimensions and shape of which differ slightly from those of the tank just described.

The walls and bottom of this tank are 9 inches thick, and the former are strengthened by 9-inch piers or buttresses spaced 8 feet apart.

When the excavation is made, a series of vertical cuts, in the sides thereof, must be excavated for the purpose of forming the buttresses.

The tank will be rendered safer against transverse cracking if it be semi-reinforced, say by barbed wire or round iron bars. The inside of the tank may be plastered with 1 : 2 cement mortar applied in a layer $\frac{1}{2}$ -inch thick.

Other Materials of Construction.—Other materials of which cattle dipping tanks may be built are:—

- (1) Stone in blue lime, pointed with 1 : 2 cement mortar;
- (2) Hard burned bricks, rendered with 1 : 2 cement mortar on the inner face of the tank.

crete)
preferred
ns may be used.

NOTE. This may be wire fence

Drying Kraal

[To face page 244.

CHAPTER XXIII

SHEEP DIPPING TANKS

THE circular sheep dipping tank about to be described is of a type which has proved satisfactory in Australia (see the *Journal* of the Department of Agriculture of Victoria, August 10th, 1910, pages 538 and 539). The inslide and decoy pen have also been thoroughly tested, and are in common use in that country. The Department of Agriculture of the Union of South Africa recommends this form of tank in preference to any other, because it is cheaper in construction; it is economical in the consumption of dipping material; and it will give better results with much less labour in dipping operations, because the sheep can be kept swimming throughout the full period of its immersion, which has a beneficial effect in that, by the movements of the sheep in swimming, its fleece is opened and the dipping mixture has an opportunity of penetrating to the skin. With the long narrow tanks usually found in South Africa such a course is not possible, because it only takes a sheep from half a minute to a minute to swim through, when it must either be pushed or held back in order to keep it immersed for the two minutes required by law. This pushing or holding back involves a great deal of labour, and when more than one sheep is placed in the tank at a time, as is generally done, the animals climb on top of one another, and can only be held back and immersed with extreme difficulty. The shoulders and backs of the sheep, being out of the dipping fluid most of the time, are not properly saturated, and thus the operation is ineffective. If the sheep are allowed out before the two minutes expire, scab will not be cured.

A circular tank, similar to that described in the following pages, was erected, under the supervision of the author, at the Experimental Farm, Potchefstroom, in conformance with the requirements of the Sheep Division as stated by Mr. B. G. L. Enslin.

The tank is supplied with a receiving yard, forcing pen, entrance race, inslide, outslope, dripping pens, and a drying yard; there is also a decoy pen for the purpose of helping to get the sheep on to the

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A circular tank, similar to that described in the following pages, was erected, under the supervision of the author, at the Experimental Farm, Potchefstroom, in conformance with the requirements of the Sheep Division as stated by Mr. B. G. L. Enslin.

The tank is supplied with a receiving yard, forcing pen, entrance race, inslide, outslope, dripping pens, and a drying yard; there is also a decoy pen for the purpose of helping to get the sheep on to the

inslide with as little handling as possible, a couple of sheep being placed in the pen to act as decoys.

As originally built the tank was 5 feet in diameter at its widest part, but this was found to be rather small, and in the accompanying plans the maximum diameter is shown as 6 feet. Such a tank is large enough to dip from four to six sheep simultaneously, according to size of breed. The tank decreases in diameter towards the bottom, which has the effect of keeping down the fluid capacity, and also the amount of building material required. The tank, if built to the dimensions given, will contain approximately 505 gallons when filled to the lip of the inslide. In order to deflect splashes back into the tank, it overhangs slightly inwards at the top. The tank itself and the outslope walls are built of bricks laid in ordinary blue hydraulic lime mortar, while the inside of the tank and outslope is rendered (or plastered) with cement mortar.

Building the Tank.—Those bricks forming the bottom of the tank are laid on edge on a layer of lime mortar deposited on the bottom of the hole which has been excavated to receive the brickwork.

The bricks forming the walls are built in heading bond, *i.e.* with their longest dimension lying across the thickness of the wall, as shown in Fig. 191, which is a quarter plan of one course of bricks. The broken lines show the position of the vertical joints between the bricks composing the next course. These joints lie halfway between the joints of the first-mentioned course. The bricks are laid in this way so as to avoid continuous vertical joints.

FIG. 191.

As a guide in the building, a wooden templet is employed, revolving about a $\frac{3}{4}$ -inch round iron rod, as shown in Fig. 192, which gives a view of the templet on the right of the iron rod, and a fully dimensioned outline of the templet on the left. The iron rod is fixed vertically by building the lower end into the brickwork forming the bottom of the tank, and passing the upper end through a hole in a wooden beam, supported at each end by a temporary brickwork pier built in lime mortar. These piers might, if desired, be displaced by wooden posts.

For the sake of cheapness, bricks of a good red variety may be used. In order to fortify them against the moisture in the surrounding earth,

the end of each brick should be dipped in hot tar before laying, and the space between the back of each brick and the excavated hole tamped in with clayey material selected from the ground excavated from the hole. It would, however, be better to use the more expensive hard-burned blue bricks, in which case the tarring operation might be dispensed with.

The bricks should be thoroughly wetted before being laid. If laid dry, they prevent the mortar from setting hard by absorbing its moisture and drying it out too rapidly. The mortar joints should not exceed three-eighths of an inch in thickness.

FIG. 192.

Building the Outslope.—In the case of the original tank, experiment demonstrated that the outslope was slightly too steep, therefore in the accompanying plans the outslope has been reduced to a slope of 30 degrees with the horizontal.

The bottom of the outslope consists of a layer of 1 to 2 to 3 concrete 3 inches thick. In the concrete, iron steps are imbedded, consisting of pieces of old tyre iron. The surface of the concrete between the steps is rendered with a $\frac{1}{2}$ -inch layer of 1 to 2 cement plaster, applied when the rest of tank and outslope is being rendered, and finished with a rough surface. The steps project 1 inch above the surface of the plaster, and are most effective. The six steps above the level of the dipping fluid are perforated with $\frac{1}{2}$ -inch holes to prevent the retention of fluid above them.

The walls of the outslope are 9 inches thick, built in English bond, *i.e.* alternate courses of headers (bricks with their length across the wall) and stretchers (bricks with their length along the wall) laid so as to avoid continuous vertical joints.

As in the circular part of the tank, those surfaces of the bricks, whether sides or ends, coming into contact with the earth, are dipped in hot tar, and selected clayey material is packed behind the bricks.

It is advisable to build a few pieces of hoop-iron into some of the horizontal joints at the corners where the walls of the outslope run into those of the tank, as there the bond is liable to be defective.

Rendering the Inner Surface.—The object of the rendering is to make the tank watertight. The cement plaster consists of one part cement to two parts clean sand. Before applying the plaster, the lime mortar in the joints between the bricks is raked out to a depth of $\frac{3}{4}$ inch in order to form a key for the plaster.

Each part of the surface of the brickwork should be well wetted before applying the plaster. This prevents the moisture from being dried out of the plaster too rapidly, and removes any dust which might prevent proper adherence of the plaster to the brickwork. The cement mortar should then be applied, being pressed hard into the brickwork.

The Inslide.—The inslide consists of a layer of 1 to 2 to 3 concrete $2\frac{1}{2}$ inches thick; on top of this a layer $\frac{1}{2}$ inch thick, consisting of one part cement to two parts granite chips, is laid; this in turn is topped by a layer about $\frac{1}{4}$ inch thick, consisting of one part cement to one and a half parts clean sand, finished as smoothly as possible with a steel floating trowel, a little dry cement having first been sprinkled in a thin layer over the surface. Some hours afterwards, the final smooth finish should be given by rubbing the surface over with the steel floating trowel.

The angle of the inslide with the horizontal shown in the accompanying drawings is a little over 30 degrees (see Fig. 197), which is slightly steeper than in the experimental tank. In the latter the inslide worked very well, but it was thought that it might be just a little steeper.

In the tank, as originally built, the inslide was 3 feet 6 inches long. This length was found to be too short, and was increased to 5 feet with satisfactory results. This is one reason why the tank is shown in the drawings as 6 feet in maximum diameter, in place of the 5 feet of the experimental tank.

The Entrance Race.—A good working width for the entrance race is 15 or 16 inches. Any animals with horns too wide to get through a race of this width may be dipped by hand. In any case there would be only a few such animals in a flock.

The side-fences of the race should be close-boarded with $\frac{3}{4}$ " boards, planed smooth on their inner face.

A curtain should be hung between the inslide and the tank, to prevent the sheep springing from the inslide right across the tank, and injuring themselves on the opposite side. The passing of the sheep along the race towards the tank is generally a difficult operation, demanding a good deal of effort on the part of the men who have to carry out the work. The curtain facilitates the above operation, probably on account of its hiding the dipping-fluid from the sheep.

It consists of a piece of tarpaulin hung from a horizontal spar and weighted by a wooden rod along the bottom.

The race is flagged and the end R, Fig. 193, concreted and smoothly plastered with 1 to 2 cement plaster, being sloped in such a way that the surface of the race merges into that of the inslope without any abrupt step or difference of level.

The race is provided with a check gate, Q, at its entrance, so that while one lot of sheep is undergoing its $2\frac{1}{2}$ minutes' dip, the next lot may be passed into, and held in the race in readiness for dipping.

The race is arranged for branding, drenching, etc., by being provided with two swing gates, M and N, and slip rails, the latter consisting of two or three rails which may be slipped through holes prepared for them in the close side-boarding of the race.

The animals after branding, drenching, etc., may be passed through gate N to the veld, or through gate M if it is desired that they be penned, or, the slip rails being removed, they may enter the dip.

The close-boarded side fences need not exceed 3 feet in height throughout the length of the race.

Forcing Pen.—The fencing of the forcing pen may be constructed of eucalyptus posts and rough wattle rails, but many farmers may prefer to use sawn rails. It would be an advantage to flag the forcing pen, as well as the race, to prevent dirt being carried into the tank by the sheep.

Decoy Pen.—The decoy pen consists of jackal wire carried on posts with 2" by 3" rails at the top and bottom. The 3" by 3"

FIG. 193.

corner post, next the circular part of the tank, does not enter the wall of the tank, but simply rests thereon, being held in position by the 2" by 3" rails already referred to. The end of the decoy pen next the inslide should have the jackal netting strongly reinforced by horizontal wires spaced about $1\frac{1}{2}$ inches apart, projecting ends of wires being avoided, as sheep sometimes jump right across the inslide and strike against this end of the decoy pen.

While the decoy sheep seldom induce a sheep to walk voluntarily on to the slide, it is found that screening the sheep in the decoy pen and in the dripping pen from the view of the entering sheep has the effect of making it considerably more difficult to get these sheep on to the inslide.

The decoy pen is provided with a small gate and is flagged.

Dripping Pens.—There are two dripping pens, each 12 feet by 16 feet, draining towards a gutter which discharges through a perforated zinc plate (which retains droppings) into a sump (see Figs. 194 and 196) where dirt may settle. From the sump a 4-inch earthenware pipe returns the droppings to the tank.

The dripping pens are filled with sheep alternately, by throwing over the diversion gate at the top of the outslope. When one dripping pen is full the sheep are left therein to drip, but meanwhile the other can be filled with sheep from the tank, so that there need be no interruption in the dipping.

The dripping pens are flagged. The flags are laid on a layer of sand or fine gravel, and the joints filled with lime mortar up to $\frac{3}{4}$ -inch from the surface. The joints are then pointed by filling the remaining $\frac{3}{4}$ -inch with 1 to 2 cement mortar.

Before making the joints each flag must be solidly bedded down on the sand, and should be tested by hitting it round the edges with a hammer, when it should not yield or cant.

The flags in the race and decoy pen should be similarly laid.

The floors of the dripping pens slope towards the gutter at the rate of 1 inch in 5 feet, and they also have a slight slope towards the line S.T. (see Fig. 193).

The gutter is formed in 1 to 2 to 3 cement concrete, plastered with 1 to 2 cement mortar, and has a slope of 1 inch in 7 feet towards the sump.

In order to prevent rain-water, which may fall on the dripping pens,

from reaching the tank by way of the sump, a rain-water outlet from the gutter is provided.

A plate, P (Figs. 194 and 195), fits into a groove in this outlet, and also into a similar groove in the spout opening from the gutter towards the sump. When dipping is in progress this plate is placed in the former groove, and when finished it is returned to the latter.

The dripping pens are fenced with jackal-proof netting. It will be noticed from Figs. 193 and 194 that three of the fencing posts pass through the concrete of the gutter. These three should be selected,

DETAIL OF IRON
PLATE "P."

FIG. 195.

SECTION THRO' SUMP

FIG. 196.

thoroughly seasoned posts, stripped of bark, and should be bedded in concrete.

Drying Yard.—From the dripping pens the sheep are passed into the drying yard, where they are held till dry enough to prevent their poisoning the pasture by dripping.

Receiving Yard.—This is for the purpose of holding the flock while the members thereof are awaiting dipping. It has an area of approximately 800 square feet.

The fence shown on the left of Fig. 193 is a rail fence of rough eucalyptus posts and wattle rails, and extends past the entrance gate, to form a wing against which the flock may be driven, thus rendering it easier to get the sheep into the receiving yard.

All fencing posts used in this and other yards should be thoroughly dry, and should have the part which enters the ground either tarred and sanded, or charred. The charring may be done over a "mest" fire, and should be allowed to penetrate to a depth of about $\frac{1}{4}$ inch, when the post should be removed from the fire and the charring stopped by throwing water over it. The remaining fencing of this yard, and of the drying yard and dripping pens, may consist of jackal netting 4 feet high, with at least fifteen horizontal wires.

Other Methods of Fencing.—The materials used for fencing will

Fig. 198.

Fig. 197.

depend on availability and cost in the district where the tank is to be erected. For instance, it may be cheaper to erect stone fences, consisting of flat stones laid in *dagga*.

Gates.—These are often made of wood, but iron gates may be used, either tubular or of other types. Iron gates would probably prove more serviceable than wooden ones. The latter, if used, should be well tarred.

The gate used in the outslope (see Figs. 198 and 199) is a gate from an old Cooper's dipping bath, and that shown in the accompanying drawings is of similar design. This gate should preferably be made entirely of iron, as a wooden gate will soon rot and fall to pieces. The balance weight may be wrapped round with sacking to prevent it from injuring the edge of the tank on which it rests when the gate is open. Perhaps a better arrangement would be to fix a piece of hardwood on the top of the edge of the tank at the spot upon which the weight descends. This block of wood may be fixed by two $\frac{3}{8}$ -inch bolts built into the wall of the tank.

SECTION ON "AB"
FIG. 199.

The brackets which support the gate are set into blocks of concrete in the side walls of the outslope. A few bricks are omitted from the walls where the brackets are to be fixed, and the latter are then concreted in place, the concrete taking the place of the bricks which were omitted.

Lime Mortar.—Consists of one part blue hydraulic lime to three parts clean sand, mixed dry till the mixture assumes a uniform colour, then mixed thoroughly with water. The mortar should then be made into a pile which is covered with sacks and left for ten days. At the end of this period the mortar may be used after first having been remixed with a little water.

Concrete.—The concrete used for this dipping tank is 1 to 2 to 3 concrete, that is to say, it consists of one part cement to two parts clean sand to three parts broken stones, small enough to pass a $1\frac{1}{2}$ -inch ring. These are mixed dry by turning over with a shovel at least twice, or until the mixture assumes a uniform colour.

Small quantities of this mixture, as required, are then thoroughly mixed with a little water and used *immediately*.

Cement Mortar.—The cement mortar used for rendering and pointing is made by thoroughly mixing one part cement to two parts clean sand first dry, and then, in small quantities as required, with water, and using at once.

Important Precautions.—All cement work should be kept damp for a period of ten days after laying by covering it with wet sacks which are rewetted at frequent intervals. This precaution is apt to be neglected, nevertheless it is of prime importance.

Construction of a Stone Tank.—The tank may be constructed in stone if suitable building stone is available. In this case the tank

FIG. 200.

may be built, as shown in Fig. 200, in lime mortar with a backing of clay rammed in behind the stones. The clay should be well puddled, or worked with water, before being rammed into place. The mortar joints between the stones should nowhere exceed $\frac{3}{4}$ inch in thickness, and cavities should be filled with chips of stone.

The inside of a stone tank need not be plastered, but the joints should be pointed with 1 to 2 cement mortar, the lime mortar having first been raked out of the joints to a depth of at least 1 inch.

List of Materials.—It is difficult, in the case of some of the materials, to estimate the quantity which will be required, as so much depends upon the individual workman in question. The following is an approximate list:—

- 1500 hard-burned blue or good red bricks.
 7 bags cement.
 5 bags blue hydraulic lime.
 4 2-ft. lengths of 4-in. earthenware pipe.

Boarding for Entrance Race.

- 8 pieces deal, 9-in. $\times$ $\frac{3}{4}$ -in., each 5 ft. 6 ins. long.
 4 " " " " 4 ft. long.
 4 " " " " 9 ft. 6 ins. long.

Rails for Forcing Pen.

- 5 pieces deal, $4\frac{1}{2}$ ins. $\times$ $1\frac{1}{2}$ ins., each 19 ft. long.
 " " " " 23 ft. long.
 100 yards 4 ft. jackal-proof netting, with fifteen horizontal wires.

Timber for Decoy Pen.

- 2 pieces 2 ins. $\times$ 3 ins. deal, each 6 ft. 6 ins. long.
 2 " " " " 8 ft. 6 ins. long.
 2 " " " " 3 ft. 6 ins. long.
 1 piece 3 ins. $\times$ 3 ins. deal, 4 ft. 6 ins. long.
 3 4-ft. iron gates.
 4 3-ft. iron gates.
 3 2-ft. wooden gates.
 1 19-in. wooden gate.
 1 revolving iron gate for outslope.
 51 fencing posts, each 7 ft. long by about 5 ins. in diameter.
 10 gallons coal tar.

The cost of the above materials will vary with locality, but will probably, in most cases, be about £30.

If a stone tank be built, less cement and more lime will be required than the quantities given in the above list.

Including labour, the total cost of the tank should not be more than from £40 to £45. The experimental tank was built by a white labourer, who was paid at the rate of 5s. per diem.

Photograph of Tank.—Fig. 201 is taken from a photograph. It shows a view of the tank, inslide, decoy pen, and dripping pens, the curtain between the tank and the inslide having been rolled up out

Fig. 201.—The sheep dipping tank at the Experimental Farm, Potchefstroom.

of the way. It also shows clearly the sump, rotating gate, and part of the outslope.

Rectangular Sheep Dipping Tank.—Drawings for a rectangular sheep

Section, A-B.

Detail of Gate

RECTANGULAR S

[To face page 259,

FIG. 202.

[To face page 259.

dipping tank and yards are reproduced in Fig. 202. The tank is built of concrete.

Graduating a Tank for Capacity.—A simple method of ascertaining the capacity of a sheep dipping tank is to measure water into it through a vessel of known capacity. First fill the dipping tank to a depth of 2 feet 6 inches, which is just sufficient to float a sheep, and make a permanent mark on the wall of the tank of the number of gallons required to do this. Then add water, 50 gallons at a time, and mark each 50 gallon level on the wall of the tank. A staff, similarly marked should be kept, in case of the graduations on the wall of the tank becoming obliterated.

In case water is added by weight, it should be remembered that 1 Imperial gallon of water weighs 10 lbs., hence 50 gallons will weigh 500 lbs.

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In case water is added by weight, it should be remembered that 1 Imperial gallon of water weighs 10 lbs., hence 50 gallons will weigh 500 lbs.

CHAPTER XXIV

SHEEP SHEARING SHEDS AND YARDS

THE author is indebted to Mr. James J. McColl, Government Wool Expert, Natal, for the notes and drawings contained in this chapter, with regard to which Mr. McColl states:—"I may, without egotism, say that the following plans and notes represent the experience gained in thirty years among sheep, in which time the writer has drafted and dipped millions of merino sheep in the earning of his daily bread."

The wool-shed illustrated by Figs. 203A, B, C, is for six shearers, and is suitable for either hand or machine shearing.

On the evening preceding, or the morning of, the day's shearing, the sheep are brought in and yarded-up in the holding yards N, N. When shearing is to commence they are forced through the forcing yards C₁, C₂, C₃, into the filling-up pens D, D, inside the shed. From the two filling-up pens, the shearer's catching pens E, E, E, are filled with sheep. Two shearers catch out of each pen. On the other side of the shearing-floor are six counting-out pens, one for each shearer. Each man passes the sheep shorn by him into his own counting-out pen. This does away with the "logie" business, and admits of each man's work being examined so that badly shorn or cut sheep can be "spotted," and ascribed to the culpable shearer, even although the superintendent may have to leave the shearing shed at times. At convenient intervals, the sheep in the counting-out pens are counted into the yard A, and each shearer is credited with his correct tally.

From the counting-out yard A, the shorn sheep, if desired, can be passed to the branding-race, and branded. After having been branded they can be sent into the receiving yard B; or, if it be not desired to brand the sheep, they may be passed direct from the counting-out yard into the yard B, until such time as it may be convenient to take them to their paddock.

When each sheep has been shorn a "boy" slips along, picks up

the fleece, and throws it on to the skirting and rolling table F, which is conveniently situated close to the shearing floor. The skirts, which may be thrown into a basket or other receptacle for the time being, are

Fig. 203A.—Wool shed and yards.

afterwards sorted into 1st and 2nd pieces on the piece-picking table G. The rolled fleeces and sorted pieces are placed in the wool bins H, to await baling in the wool press, which stands just in front of the

bins to avoid the necessity of carrying the wool over excessive distances. The bales, on leaving the press, are branded, and stored in the space opposite the wool-bins ready for loading on to waggons through the end door of the shed.

The sweating pen K, which is under cover, is useful in showery weather for holding sheep awaiting shearing. It may also be used for the reception, after dipping, of sheep which may be suffering from excessive heat, or which must be placed under cover to escape a gathering storm; these sheep may enter through the gate M. The sweating-pen is also a suitable place for hoof-trimming, drenching, or sheep-classing, on account of its being under cover. The floors of all the pens in the shed are of 3" by 1" hard-wood battens, spaced with openings $\frac{5}{8}$ inch wide between them, for the purpose of allowing droppings and urine to pass through. This helps to keep the sheep clean should they lie, or fall, down. The flooring should be made in sections of about 5 feet by 8 feet in size, which can be lifted periodically in order to allow of the removal of the manure which accumulates underneath. The spaces between the battens should not exceed $\frac{5}{8}$ of an inch in width. If made wider than this, the wearing away of the edges of the boards will, in time, allow the feet of small lambs to pass through and broken legs will result.

Sheep which are to be dipped are also yarded into the holding yards N, and are then forced through the forcing pens P_1 and P_2 , into the circular dipping tank. From the dipping tank they climb into the dripping pen R, from which, after they have dripped sufficiently, they are allowed into the drying yard S, and also into the yard T if more yard room be required. If weather conditions call for it, however, the sheep, on leaving the dripping pen, may be passed into the covered sweating pen. The yard V can be used in conjunction with either yard N or T.

For drafting purposes the sheep can be yarded-up into the yard V, thence they would be sent through yard T, the drying yard S, the forcing pens W_1 and W_2 , and the drafting race to the drafting gate Y, by means of which they can be sent into either of the yards N.

Of course, if it be desired to draft sheep after their having been dipped, they may be passed from the drying yard S, through W_1 and W_2 , to the drafting race and gate Y.

The fencing of all forcing-pens and races should be constructed

entirely of timber (either rails or palings may be used) so as to stand the pressure of hard forcing, for which purpose wire netting is not strong enough. All other fences *may* be made of good wire netting, strongly backed by six well strained plain wires.

The drafting race should be 24 inches wide at the entrance and 20 inches at the exit. Its length should be at least 12 feet, though 15 feet is preferable. The fences forming this race should be at least 3 feet 6 inches high and "blind," *i.e.* the sheep should not be able to see through them. The drafting gate Y should be 5 feet long and swing against the two posts at the exit from the race. If the drafting gate be

FRONT ELEVATION.

FIG. 203B.

SIDE ELEVATION.

FIG. 203c.

not made "blind," then the spars should not be further apart than 4 inches, so that small sheep may be prevented from getting their heads through the gate.

The branding race should be about 4 feet wide and from 20 to 25 feet long, with one of its side fences 3 feet 6 inches high to admit of a man leaning over it. When sheep are to be branded, the race should be jammed full, the heads of the sheep will then all face in the same direction, viz. towards the outlet gate. The man who is branding remains outside of the race, and does his work *over* the 3' 6" fence. He carries a pan of tattoo oil in one hand (an old frying pan forms an excellent receptacle for the oil) and a short-handled hand-brand in the

other. He commences at the outlet gate, and brands right along till he comes to the entrance gate. The sheep are then allowed to enter the yard, B, where they are held till such time as they can conveniently be removed.

If the plan (Fig. 203A) be examined, it will be seen that the fence which forms *one* side of any particular set of forcing pens and race is quite straight. In yards made in this way the sheep run beautifully, because they can see where they are going a good way ahead, and follow each other at a smart pace. "Funnel-shaped" forcing pens cause the sheep to jam at the mouth of the race, and give rise to extra work and unnecessary knocking-about of the sheep.

Sheep possess memories; they object to being again penned-up towards the dipping tank where they have had a good "sousing" on some previous occasion; they hang back through fear. For this reason it is desirable to have the forcing pens for drafting different from those for dipping. Once sheep have been through the drafting race they do not fear it next time. There are no unpleasant memories attached to it—just a recollection of a pleasant scamper through.

If sheep be caused to use the same gate, both as entrance to and exit from any yard, they are apt to develop the bad habit of "breaking back" from the gate (on their being driven towards it with the object of getting them to enter the yard), because they recollect that the last time they were there they were scampering *away* from the yard. The provision of two gates in each yard, one of which is always used as entrance and the other always as exit, goes a long way towards stopping the above-mentioned habit of breaking back.

In the accompanying plan both sides of every fence, with the exception of the outer fence, are made use of. It will also be noticed that any dust which is raised in the yards, is well away from the wool tables, bins, etc., which is a great desideratum. The back wall of the shed, with the exception of the door M, contains only windows to admit light to the batten-floor pens.

Machine Shearing.—Should it be desired to instal shearing machines, the accompanying plans, Figs. 204A, B, C, will show how the engine, shafting, and grinder may be arranged. The shafting must be placed *at least* 1 foot out from the uprights, to admit of the backward swing of the shearing tube when the shearer is at work. Different makes of machines are slightly differently installed, but that does not alter the

general planning and arrangement. The agents for the machine decided upon will attend to the necessary erecting. It is usual, in this country, to have the shearing tubes 6 feet in length; but, as a consequence, the swing round of the tube in shearing is rather limited, because the height

FIG. 204A.—Wool shed for machine shearing.

of the fixed point is too low. Shearing is made easier by having the cores and tubes at least 7 feet long, and fixing the shafting correspondingly higher.

The bearings for the shafting must be truly lined up, and free from excessive vibration. A particularly firm and strong arrangement is that shown in Figs. 204A, B, C, where the brackets, which carry the bearings, are bolted to a 3" by 9" deal crossing, and bolted to, the uprights.

There should be a fair sized window, about 3 feet by 2 feet 6 inches, in front of the lean-to which contains the engine and grinder. This allows of good grinding being accomplished. A good light is necessary, as the combs and cutters are very easily destroyed by careless grinding. The grinder, it will be noticed, is installed close to the engine, away from the shearing floor.

FIG. 204B.

A six-shearer outfit, such as that illustrated, can be driven easily by a $4\frac{1}{2}$ horse-power oil engine. When not being used to drive the shearing machines, the engine can be utilised for the performance of other farm work.

FIG. 204c.—Interior elevation, showing front of catching pens, shafting, and engine-room.

Exclusive of the engine, the approximate cost of a shearing installation ranges from £10 to £16 per unit, for small sheds. The above price includes all shafting, pulleys, friction wheels, shearing tubes and hand-piece, also spare combs and cutters, per shearer.

CHAPTER XXV

DRAINAGE

DRAINAGE OF DWELLING HOUSES AND STOCK HOUSES

THE importance of efficient sanitary arrangements for the disposal of slop-water, liquid-manure, etc., is so evident that it scarcely needs emphasizing. The drains for the purpose usually consist of smooth, salt-glazed, stoneware pipes 4" or 6" internal diameter. It is not advisable to employ drain pipes of a smaller diameter than 4 inches. These stoneware pipes are made in lengths of about 2 feet. One end of each pipe, known as the *faucet* or *socket*, is enlarged in diameter. The other (unenlarged) end is called the *spigot*. When the pipes are laid, the spigot of one pipe enters the faucet of the adjoining pipe, the joint being sealed with 1 : 1 cement mortar. Pipes should always be laid with their spigot end downstream, and care should be taken to lay the pipes truly in a straight line, and at a uniform slope or fall, between inspection chambers (to be described later). They must also be laid concentrically, or in true alignment, so that no ridge or shoulder is left at the joints. Such ridges are apt to cause deposits in, and consequent blocking of, the pipes. Attention must also be paid to the removal of any projecting mortar, which may have been squeezed into the interior of the pipes from the joints while the latter were being made. It is preferable to lay all drain pipes in concrete, to diminish risk of breakages. If this be not done, the drain-layer should at least rest each joint on a brick placed underneath it, and should ram the earth about each joint with special care; all stones should be removed from earth which is to be rammed next to the pipes.

In order to prevent deposit in the pipes, 4-inch drains should have a fall of not less than 1 in 40, 6-inch drains 1 in 60, and 9-inch drains 1 in 100. When these gradients cannot be obtained (on account of the flatness of the ground) special facilities should be provided for the

purpose of flushing the drains, and this operation should be performed once or twice per week.

No drain should be constructed under any building unless that course is quite unavoidable. Should it be imperatively necessary to construct such a drain, it should be laid in a straight line for the whole distance under the building, and the pipes composing it should be imbedded in, and covered with, good cement concrete at least 6 inches thick all round the pipe, and an inspection chamber, which will permit of the insertion of cleaning rods or wire, should be provided at each end of the part of the drain that is under the building.

Wherever any change of direction, or sudden fall, occurs in a drain-pipe line, an inspection chamber should be constructed.

It is desirable that an inspection chamber should be constructed where any branch or tributary drain joins another drain. The tributary drain should join the other obliquely in the direction of flow, and not at right angles.

In positions near buildings, where the escape of foul sewer gas would be insanitary, and would tend to create a nuisance, inspection chambers should be fitted with air-tight covers.

The entrance to any drain pipe should be trapped by an *intercepting* or *gully* trap, so constructed (in the form of a U pipe) that there is always a liquid seal therein, which prevents evil-smelling sewer gases from entering the dwelling or stock house served by the drain.

An ordinary *square gully trap* is shown in Fig. 205. Such a gully trap can also be had round, and is suitable for the reception of bath

FIG. 205.

FIG. 206.

water. Gully traps are placed at ground level, and have their mouths surrounded by a curb either of hard bricks on edge rendered with cement plaster, or of concrete.

A *stable gully trap* is illustrated by Fig. 206. It is provided with a perforated tray,

which intercepts solid matter and can be withdrawn at intervals for the purpose of emptying it of the said solids.

The discharge from a kitchen sink takes place, through a layer of filtering grass, into a *grease trap* which also acts as an *intercepting trap*,

as shown in Fig. 207. The grease trap is provided with a perforated tray or baler, similar to that in a stable gulley trap, which intercepts solids.

FIG. 207.

The discharge from a cow-byre may be arranged to take place into a sump (or two sumps in the case of a double byre) in which solid matter settles. The sewer gases are shut off by an intercepting trap, such as that shown in Fig. 208.

In all the above cases the discharge into gulley, trap, or sump, should take place freely in the open air.

Any reasonable length of drain pipe should be ventilated, and for that purpose fresh air inlets and foul air outlets should be provided. These are shown in Fig. 207. The ventilation prevents the accumulation, and consequent rise in pressure, of sewer gas. Were the pipes not ventilated, the gas might force its way past the water seal into the dwelling or stock house served by the drain. A fresh air inlet is provided with a light flap of mica which opens inwards only, and thus, while allowing of the free ingress of fresh air, prevents the egress of sewer gases. The mica flap and its containing box are carried on the top of a length of iron pipe, which is supported by a $4\frac{1}{2}$ " by 3" wooden post placed behind it. Sometimes, in place of this wooden post, the ventilating pipe is supported in a block of concrete at its base.

A foul air outlet consists simply of an iron pipe carried well above

FIG. 208.

any adjoining roofs and windows, so as to ensure the escape of the foul air and gas into the upper atmosphere. Foul air pipes may be supported by any adjoining building, wall, or tree. The top of the foul air pipe should be protected, against birds nesting in it, by a wire balloon or cap as shown.

Ventilation pipes should not be much, if any, smaller than the drain pipe which they ventilate. They should never be less than $3\frac{1}{2}$ " in diameter internally. They may be jointed to the stone ware pipes with bitumen.

Example of the Disposal of Slop-Water from a Kitchen Sink.—Fig. 207 illustrates the arrangements for this purpose. The outlet or waste pipe from the sink is trapped and carried through the wall, that part in, and

FIG. 209.

on the outer side of the wall, being of iron. At the lowest point, O, of the waste-pipe trap, an orifice should be formed, fitted with a screw plug which can be removed for cleaning purposes in the event of the waste pipe becoming choked. These points are better shown in Fig. 209. The waste pipe discharges openly over a *filter bucket*, which consists of a square galvanised iron box, without a lid and with a perforated bottom, about 12" square in plan and 12" deep. In this box a layer of dried grass is placed, which roughly filters the slop water before it passes into the drain. The filtering material should, of course, be renewed frequently.

The roughly filtered slop-water falls from the filter bucket, through an iron grating and a stoneware hopper, into the grease trap shown, which contains a zinc baler or perforated tray for the interception and removal of any solids that may have passed the filter bucket. As will

be clear, from the water-seal shown shaded in the drawing, the grease trap acts also as an intercepting trap which shuts off foul sewer gases and prevents their entering the house.

CE is a *cleaning eye* to give access to the drain for cleaning purposes. Since it is on the down-stream side of the water seal, it must be airtight. The stoneware lid is therefore sealed by a thin layer of 1 : 1 cement mortar on top of it, which can easily be broken when the eye requires to be opened to give access to the drain.

It will be noticed that the grease trap, hopper, etc., are bedded in concrete, and that a concrete curb is formed, round the mouth of the hopper, on which the filter bucket sits.

A 6-inch diameter grease trap 24 inches deep, such as that shown, with grating, hopper, and perforated tray complete, costs about 32s. in Johannesburg. Grease traps can also be had 9 inches, and 12 inches in diameter. Like the other stoneware goods mentioned in this chapter they are manufactured in South Africa.

Immediately down-stream of the grease trap, a foul air outlet pipe, takes off, which may be attached to one of the walls of the building and should rise a few feet above the eaves of the roof and above all windows.

The 4-inch drain pipe should have a fall of not less than 1 in 40. If it discharges freely in air, say into some water-course, no special fresh-air inlet will be required, since the open end of the pipe itself will serve for this purpose. If, however, it discharges into a French drain, a mica flap fresh-air inlet should be provided near the end of the drain pipe, close to the French drain, as shown.

A *French drain*, sometimes called a *Vivian Poore* drain, is a device much used in South Africa for effectively getting rid of slop water. In its simplest form it consists of a trench dug in the ground and filled, to a level just above the end of the drain pipe entering it, with rough stones of about the size indicated in the drawing (Fig. 207). These stones are covered with a few sheets of corrugated galvanised iron, arranged so as to prevent sand or earth from falling into the trench. The corrugated iron sheets are covered with a layer of earth to the original ground level. It should be evident that a French drain will be more efficient in light sandy or loamy soils, than in clayey ground. The size of French drain required depends mainly on the nature of the soil, and on the amount of slop-water to be disposed of. An ordinary

size, for the disposal of kitchen slop-water, is 20 feet long, by 2 feet wide, by 3 feet deep (depth of stones).

So as to guard against dampness in the foundations of the house, it is desirable not to have the nearest part of the French drain closer than 20 feet from the house, though in some cases the distance from the house is less than this.

If the drain pipe (leading, say, to some water-course) be a long one, or if it has a change (or changes) of direction in it, then the usual inspection chambers, or cleaning eyes, should be provided. These will be described shortly.

Simpler Arrangements for the Disposal of Kitchen Slop-water.—A simpler type of grease and intercepting trap is illustrated by Fig. 209. It consists of a concrete well, divided by the slab S into two chambers A and B. The mouth of chamber A is surrounded by a concrete curb on which the filter bucket sits, and is covered by an iron grating; or even a piece of galvanised iron perforated by a number of holes would do in place of the grating.

Chamber B must be airtight, and from near the top of it the drain pipe takes off.

Solid matter, which accumulates on the bottom of the two chambers, must be removed by baling from the chamber A.

The inside surfaces of the trap should be plastered as smooth as possible, but since the smoothness of the surface thus obtained cannot nearly equal that of the glazed stoneware trap last described, the latter will be much the more sanitary.

Inspection Chambers.—A typical inspection chamber, at a right-angle change of direction, is shown in Fig. 210. The bottom is of concrete, and the walls are of 9-inch brickwork topped with concrete, into which is built the iron frame to receive the cast-iron air-tight inspection cover. The inside of the chamber is finished, as smooth as possible, in cement plaster.

The inspection cover has a projecting flange or rib formed on its lower face, near the edge. This flange projects into a channel or chase formed in the frame, being pressed into the stiff grease with which the chase is filled, to make the joint air-tight.

The course of the drain is continued across the bottom of the inspection chamber by means of a half-section, white-glazed channel of the same diameter as the drain pipe. That part of the bottom of the

inspection chamber which is not occupied by the channel should be well benched-up in concrete and sloped towards the half-section channel, so as to confine the sewage, as far as possible, to the latter, its proper course. White-glazed, half-section, stoneware channel-pipes are manufactured for the above purpose.

In the case of an inspection chamber, where a tributary drain joins a main drain, the invert of the tributary channel should be slightly higher than that of the main channel, so that the former will discharge *over* the latter. If branch drains enter the inspection chamber from opposite sides, the branch channels should be arranged so that they do not discharge (into the main channel) immediately opposite each other.

Inspection chambers should be large enough to allow of the insertion of cleaning rods or wire. The chamber shown is 18 inches square. If,

FIG. 210.

however, the drain lies deeply in the ground, the inspection chambers should be larger.

In the case of a large inspection chamber, there is no need to have the inspection cover larger than 24" by 24" (the largest size commonly stocked by merchants), because the brickwork can be corbelled inwards towards the top, so as to diminish the orifice to suit the size of cover.

An 18" by 18", cast-iron, single-seal manhole cover, such as that

in Fig. 210, costs about 15s. 6d. in Johannesburg.

FIG. 211.

Cleaning Eyes.—Two types of cleaning eye are illustrated. That in Fig. 211 consists of an oval eye in the pipe, closed by a stoneware lid, the joint being sealed with bitumen. This type is suitable when the pipes are near the surface of the ground.

If the pipes lie deeper, the type illustrated by Fig. 212 should be used. It consists of a junction pipe, together with an easy bend that extends nearly to the surface of the ground, and which has its upper end closed by a stoneware plug sealed with bitumen.

Both types of cleaning eye may be marked, and covered, by a concrete or stone slab carried on a brick-on-edge curb, as shown in Fig. 212.

As has already been mentioned, inspection chambers should be situated at points where the pipe line changes direction. Further, if a straight length of pipe exceeds 50 feet in length, cleaning eyes should be provided not more than 50 feet apart. An inspection chamber in a straight section of pipe can, however, always take the place of a cleaning eye, and it is advisable that such an inspection chamber should occur at intervals in a very long length of drain.

FIG. 212.

Cleaning rods are sold which are made in sections, each about 3 feet long, so that they can be got into the drain at an inspection chamber. The various lengths, or sections, screw together to form one long rod. Various cleaning devices are manufactured for attachment to the end of the cleaning rod, such as scrapers, brush-heads, plungers, double worms, etc. If, however, the drains have been properly laid, and cleaning eyes and inspection chambers are situated as close together as mentioned above, and if the drains are regularly inspected and cleaned if necessary, a stiff wire will generally be found sufficient for the latter purpose.

Drainage from Stock Houses.—From these points where liquid manure has been conducted out of stock houses, drain pipes should be laid leading either to a main system of drainage, or to a liquid manure tank, the contents of which will ultimately be applied to the land. For this purpose 4-inch glazed stoneware pipes are sometimes employed, but for larger stock houses, if the pipe line be at all long, 6-inch pipes are to be preferred.

For example, the liquid manure and washings, from the open manure channels inside the cow-byre, discharge in the open air, *outside of the cow-byre*, into sumps, as shown in Fig. 208, and at S, S, in the frontispiece. The drain pipe which leads from the sumps should be trapped, and just

down-stream of the intercepting trap a foul air outlet pipe should take off. This pipe may be attached to the end wall of the cow-byre, and should be carried well above the eaves of the roof. Its upper end should be protected by a wire balloon. In Fig. 208 a standard intercepting trap is shown, fitted with a cleaning arm with air-tight plug, and a vent for the foul air pipe.

The sumps are shown with a concrete bottom, and 9-inch hard brick walls rendered on the inside with cement mortar. They are provided with a concrete top recessed to receive a stone or concrete slab cover, though a cast-iron cover, as shown in Fig. 210, may be fitted if desired. Each sump should have its bottom at least 18 inches below the centre-line of the drain pipe leaving it, so as to trap solid manure and prevent it from getting into the drain pipe.

If the other end of the drain discharges freely in air into the liquid manure tank, no special fresh air inlet will be required there.

The drainage from other buildings should discharge into similar sumps, connecting with the main drain. In Fig. 156A the sumps which receive the piggery drainage are shown covered by iron gratings.

The liquid manure tank, adjacent to the dung-stead, may be constructed entirely of concrete, or the walls may be built of hard-burned bricks, rendered with cement plaster. From the tank the liquid manure may be pumped, and distributed over the dung in the dung-stead so as to improve the manurial value of the latter. Or, alternatively, the liquid manure may be led over the land. The urine, as a rule, will be sufficiently diluted for use for irrigating purposes, by the water used in washing out the stock houses which finds its way into the drains.

The only really satisfactory type of liquid manure pump is one the working part of which consists of a number of cast-iron discs attached at intervals to an endless chain (see Fig. 213). When the pump is operated these discs pass upwards through the delivery pipe, carrying between them the liquid to be elevated. This type of pump has no valves to cause trouble by becoming choked.

The dung may be confined to the dung-stead by dwarf walls. In order to prevent the impoverishment of the manure by the action of the weather, the ideal dung-stead should be roofed. It should also have an impervious floor sloping towards, and draining into, the liquid manure tank. Flies lay their eggs in the dung if they can gain access to it, in fact heaps of stable manure are their favourite breeding places.

To keep down flies the space between the top of the dwarf walls, surrounding the dung, and the roof should be fly-netted, and fly-doors should be fitted to give access to the dung-stead. Receptacles containing poison bait, laid on top of the dwarf walls, inside the fly-netting, will also help towards the abatement of the fly nuisance. A few acacia or eucalyptus branches hung on the outside of the fly-netting, and sprayed with poison bait, will account for many of the flies which are attracted towards the dung-stead as a suitable place in which to deposit their eggs. The sill of the fly-doors, which give access to the dung-stead, should be raised by about 6 inches above the impervious floor of the dung-stead, so as to present a vertical step that will be an insurmountable barrier to fly maggots, which naturally try to crawl away from the manure in order to develop into flies.

FIG. 213.

The dung, of course, should not be allowed to touch the step, but a clear space between manure and "step-up" should be preserved.

Failing the above rather elaborate arrangements, much can be done to keep down flies by covering the dung with leafy branches sprayed with poison bait. The bait should be prepared according to the following formula, recommended by Mr. C. W. Malby :—

Arsenite-of-soda	...	...	...	6½ ozs. (av.)
Sugar (cheapest grade)	...	...	...	4 lbs.
Water	...	...	...	4 galls.

CHAPTER XXVI

SHORT NOTES ON ESTIMATING QUANTITIES—WORKING DRAWINGS FOR A SMALL COTTAGE

A FEW words on taking out quantities may be helpful to the farmer, though no attempt at a comprehensive treatment of the subject will be made.

Estimating Brickwork.—In calculating the number of bricks required for a building the following procedure may be adopted :—

- (1) Calculate the number of square yards of wall.
- (2) Allow 90 bricks per square yard in the case of a 9-inch wall ; and 140 bricks per square yard in the case of a 14-inch wall.

These allowances are approximate only.

The method will be best illustrated by an example.

Example.—A brick wall is to be 12 feet high, by 30 feet long, by 14 inches thick. Calculate the number of bricks required to build the wall.

- (1) The number of square yards of wall is found by multiplying the height of the wall in *yards* by its length, also in *yards*.

Now the height is 12 feet, or 4 yards, while the length is 30 feet 10 yards, therefore—

$$\text{Number of square yards of wall} = 4 \times 10 = 40$$

- (2) Allowing 140 bricks per square yard of wall, the total number of bricks required will be found by multiplying the number of square yards of wall by 140, thus—

$$\text{Total number of bricks required} = 40 \times 140 = 5600 \text{ answer.}$$

Quantities of Materials required for the Mortar for Brickwork, Rubble Masonry, Pointing, and Plastering.—One cubic yard of lime, 3 cubic yards of sand, and 150 gallons of water make 71 cubic feet of 1 : 3 mortar, which is sufficient to lay 4350 bricks.

Thus the quantity of lime required for the above wall = $\frac{5600}{4350} = 1.3$ cubic yards.

The quantities of lime and sand required for mortar for rubble masonry may be calculated from the relation that 1 cubic yard of rubble masonry requires from $\frac{1}{6}$ to $\frac{1}{5}$ of a cubic yard of mortar.

One-fourth of a cubic foot of mortar will point 1 square yard of brickwork in English bond.

The quantities of cement and sand required to make the mortar for pointing any particular area of brickwork may be calculated from the table on p. 135, according to the richness of the mortar to be used.

For a plaster coating of 1 : 3 lime mortar having an average thickness of $\frac{3}{4}$ inch, we may assume that 1 cubic foot of lime will be required for each 4 square yards of surface of brickwork to be covered.

Concrete.—In order to calculate the quantities of cement, sand, and broken stone required for a concrete wall, or floor, etc., we must—

- (1) Calculate the volume of the wall or floor in question. It will be convenient to express this volume in cubic yards. In the case of a wall the volume will be

$$= \text{length in yards} \times \text{height in yards} \times \text{thickness in yards};$$

and in the case of a floor

$$= \text{length in yards} \times \text{width in yards} \times \text{thickness in yards.}$$

- (2) Select from the table on p. 130 the figures corresponding to the relative proportions of cement, sand, and broken stone which it is desired to use, and multiply each of these figures in turn by the number of cubic yards in the wall or floor. The results will represent the total quantities of cement (barrels), sand (cubic yards), and broken stone (cubic yards), which will be required.

Example.—A concrete floor is 90 feet long, by 30 feet wide, by 4 inches thick. The concrete is to be mixed in the proportions 1 : 2½ : 5, i.e. 1 part cement, to 2½ parts sand, to 5 parts broken stone. Calculate the quantities of cement, sand, and broken stone required.

- (1) Length of floor = 90 feet = 30 yards;
 Width „ = 30 feet = 10 yards;
 Thickness „ = 4 inches = $\frac{1}{3}$ yard.

Hence—

$$\begin{aligned} \text{Volume of floor} &= 30 \times 10 \times \frac{1}{3} \\ &= 33.3 \text{ cubic yards.} \end{aligned}$$

- (b) The thick outer part of the base of the silo (*i.e.* the footing for the wall) may similarly be treated as a hollow cylinder of external diameter, 18' 4''; internal diameter, 11' 0''; height, 1' 0''.
- (c) The thin inner part of the base (*i.e.* the floor of the silo) may be looked upon as a solid cylinder of diameter, 11' 0''; and height 4 inches.
- (a) $15' 10'' = 15\frac{10}{12}' = 15\frac{5}{6}' = \frac{95}{6}$ feet.

Let us call the volume of the external cylinder V_e , then—

$$V_e = \frac{\pi \times 95 \times 95}{4 \times 6 \times 6} \times 30$$

by substituting in formula (I.), hence—

$$V_e = 5904 \text{ cubic feet.}$$

Again substituting in formula (I.), and calling the volume of the internal cylinder V_i , we have—

$$V_i = \frac{\pi \times 15 \times 15}{4} \times 30$$

$$V_i = 5299 \text{ cubic feet;}$$

hence—

$$\begin{aligned} \text{Volume of wall} &= V_e - V_i \\ &= 5904 - 5299 \\ &= \mathbf{605 \text{ cubic feet.}} \end{aligned}$$

- (b) $18' 4'' = 18\frac{4}{12}' = 18\frac{1}{3}' = \frac{55}{3}$ feet, hence, in this case—

$$V_e = \frac{\pi \times 55 \times 55}{4 \times 3 \times 3} \times 1$$

$$V_e = 264 \text{ cubic feet.}$$

and—

$$V_i = \frac{\pi \times 11 \times 11}{4} \times 1$$

$$V_i = 95 \text{ cubic feet;}$$

hence—

$$\begin{aligned} \left. \begin{array}{l} \text{Volume of thick outer part} \\ \text{of base (i.e. wall footing)} \end{array} \right\} &= V_e - V_i \\ &= 264 - 95 \\ &= \mathbf{169 \text{ cubic feet.}} \end{aligned}$$

- (c) $4'' = \frac{4}{12}' = \frac{1}{3}$ foot

therefore—

$$V = \frac{\pi \times 11 \times 11}{4} \times \frac{1}{3}$$

$$V = 32 \text{ cubic feet nearly;}$$

that is—

$$\left. \begin{array}{l} \text{Volume of thin inner part} \\ \text{of base (i.e. floor of silo)} \end{array} \right\} = 32 \text{ cubic feet.}$$

Therefore,

$$\begin{aligned} \text{Total volume of concrete in silo} &= 605 + 169 + 32 \\ &= 806 \text{ cubic feet.} \end{aligned}$$

Now there are 27 cubic feet in a cubic yard, hence—

$$\begin{aligned} \text{Total volume of concrete in silo} &= \frac{806}{27} \\ &= 29.8 \text{ cubic yards.} \end{aligned}$$

Referring to the table on page 130 we find that 1.57 barrels of cement are required for 1 cubic yard of 1 : 2 : 4 concrete; therefore the quantity of cement required for 29.8 cubic yards of concrete

$$\begin{aligned} &= 1.57 \times 29.8 \\ &= 47 \text{ barrels,} \\ &\text{or } 94 \text{ bags.} \end{aligned}$$

Again referring to the table on page 130, we see that 0.44 cubic yard of sand is required per cubic yard of 1 : 2 : 4 concrete, hence—

$$\begin{aligned} \text{Sand required for } 29.8 \text{ cubic yards concrete} &= 0.44 \times 29.8 \\ &= 13.1, \text{ say } 13\frac{1}{4} \text{ cubic yards;} \end{aligned}$$

and,

$$\text{broken stone required} = 26\frac{1}{2} \text{ cubic yards.}$$

Cement Plaster or Mortar.—For the purpose of calculating the quantities of materials required for cement plaster or mortar, made with fine sand, the table given on page 135 may be used.

Example.—A concrete wall 120 feet long by 8 feet high is to be rendered on one side with a coat of cement plaster averaging $\frac{3}{4}$ inch in thickness. The plaster is in the proportion 1 part cement to 3 parts fine sand. Calculate the quantities of cement and sand required.

Volume of compacted plaster in cubic yards

$$= \left\{ \begin{array}{l} \text{length of wall} \\ \text{in yards} \end{array} \right\} \times \left\{ \begin{array}{l} \text{height of wall} \\ \text{in yards} \end{array} \right\} \times \left\{ \begin{array}{l} \text{thickness of plaster} \\ \text{coat in yards} \end{array} \right\}$$

$$\text{Now, length of wall} = 120' = 40 \text{ yards}$$

$$\text{height „} = 8' = \frac{8}{3} \text{ yards}$$

$$\begin{aligned} \text{thickness of plaster coat} &= \frac{3''}{4 \times 36} \text{ yard} \\ &= \frac{1}{48} \text{ yard.} \end{aligned}$$

Therefore, volume of compacted plaster $= 40 \times \frac{8}{3} \times \frac{1}{48}$
 $= \frac{20}{9}$ cubic yards.

From the table on page 135 we find that 1 cubic yard compact plastic, 1:3 mortar requires 2.37 barrels cement, and 1.00 cubic yard sand; hence—

Cement required for $\frac{20}{9}$ cubic yards mortar $= 2.37 \times \frac{20}{9}$
 $= 5.27$ barrels
 or say $5\frac{1}{2}$ barrels, or 11 bags.

Sand required for $\frac{20}{9}$ cubic yards mortar $= \frac{20}{9} = 2\frac{2}{3}$ cubic yards.

If coarse, unscreened sand be used for making mortar, the following table should be employed for the purpose of estimating the quantities of materials required.

MATERIALS FOR 1 CUBIC YARD COMPACT PLASTIC MORTAR, MADE WITH COARSE SAND (APPROXIMATE).

Proportions by volume.		Packed cement, barrels.	Loose sand, cubic yards.
Cement.	Sand.		
1	$1\frac{1}{2}$	4.00	0.84
1	2	3.32	0.93
1	$2\frac{1}{2}$	2.84	1.00
1	3	2.48	1.05

Cement required for laying Bricks.—One cubic foot (90 lbs.) of loose Portland cement to three of sand will lay about 212 bricks with $\frac{3}{8}$ " joints, and 317 bricks with $\frac{1}{4}$ " joints.

Quantities of Timber, Corrugated Iron, etc.—The taking out of these quantities is mainly a matter of making measurements from the drawings.

If no drawings exist, however, the estimates must be prepared from the known dimensions of the proposed building under consideration; in this case one is much more apt to forget items than when proper drawings are available.

In estimating quantities of timber, allowance should be made for the fact that the ends of boards and deals often contain shakes which run into the wood for some distance, and that it may be desirable to cut these ends off.

In estimating corrugated iron, allowance should be made for the necessary overlaps, and for projecting eaves, etc. In ordering this material a good brand should be specified.

FIG. 214.—Working drawings for small stone cottage.

Quantities of Material for Paint.—A table of quantities of ingredients, and the approximate areas which the resulting paint will cover, is given on page 110.

Tarring.—One gallon of tar, with 1 lb. of pitch included, when applied

FIG. 214B.

FIG. 214C.

hot to wood, will cover about 12 square yards the first coat, and about 17 square yards for each succeeding coat.

Lime-whiting.— $1\frac{1}{2}$ cubic feet of lime will coat 100 square yards once; 2 cubic feet of lime will coat 100 square yards twice.

Drawings for a Small Cottage.—Working drawings for a small stone cottage are reproduced in Figs. 214A, B, C, and Figs. 46 and 47. These drawings should be useful as an example of ordinary building construction. A small cottage has been chosen, on account of its being possible to show the drawings therefor on a larger scale than would have been admissible in the case of a bigger house; after all, the building construction in a large house is much the same as in a small one.

A list of materials for this cottage is appended. Materials for painting and decorating are not included.

LIST OF MATERIALS FOR STONE COTTAGE SHOWN IN FIGS. 214A, B, C, 46, AND 47.

Timber.

Baltic deal except when otherwise stated.

Name of part.	Cross-sectional dimensions.	Length.	Number of pieces.
Flooring joists	4½" × 1½"	14' 0"	12
" "	"	12' 0"	8
" "	"	11' 0"	7
Sleepers	4½" × 3"	12' 0"	8
" "	"	9' 0"	4
Flooring boards	6" × 1"	12' 0"	58
" "	"	9' 0"	22
Ceiling boards	6" × ¾"	14' 0"	26
" "	"	12' 0"	26
" "	"	11' 0"	20
Skirting boards	7" × 1"	13' 0"	2
" "	"	12' 0"	3
" "	"	11' 0"	2
" "	"	10' 0"	2
" "	"	9' 0"	1
" "	"	8' 0"	2
Cornice	4" wide	15' 0"	2
" "	"	13' 0"	6
" "	"	12' 0"	2
" "	"	10' 0"	2
" "	"	8' 0"	1
Door architraves	"	15' 0"	6
" "	"	7' 0"	3
Window architraves	"	12' 0"	4
" "	"	10' 0"	2
Ceiling joists "	4½" × 1½"	13' 0"	7
Tie beams	"	15' 0"	7
Rafters	"	13' 0"	7
" "	"	9' 0"	14
" "	"	10' 0"	7
Purlins	3" × 2"	18' 0"	11
" "	"	15' 0"	11
" "	"	16' 0"	9
Ridge board	6" × 1½"	17' 0"	1
" "	"	16' 0"	1
King posts and collars	4½" × 1½"	9' 0"	7
Wall plates	4½" × 3"	14' 0"	4
" "	"	12' 0"	1
" "	"	15' 0"	3
Verandah posts	"	8' 0"	5
" "	3" × 3"	9' 0"	1
Fascia boards	9" × 1"	17' 0"	1
" "	"	15' 0"	1
" "	6" × 1"	9' 0"	6
" "	"	12' 0"	1

Name of part.	Cross-sectional dimensions.	Length.	Number of pieces.
Fascia boards	7" × 1"	12' 0"	1
" " " " " " " "	" " " " " " " "	7' 0"	1
Mantelpieces (clear pine)	12" × 1½"	10' 0"	1
Edging for hearths	3" × 2"	11' 0"	1
" " " " " " " "	" " " " " " " "	13' 0"	1
Shelving boards	12" × 1"	6' 0"	4
Shelving uprights	3" × 1½"	8' 0"	6
Picture rail	" " " " " " " "	14' 0"	2
" " " " " " " "	" " " " " " " "	15' 0"	2
Window boards	7½" × 1½"	4' 6"	4
Lintels for inside doors	4½" × 3"	5' 0"	6
Capping boards for roof	6" × 1½"	9' 0"	6
" " " " " " " "	" " " " " " " "	13' 0"	1
Jambs for inside doors	3" × 2"	7' 0"	10
" " " " " " " "	" " " " " " " "	10' 0"	3
Stops for inside doors	7½" × ½"	3' 0"	1
" " " " " " " "	" " " " " " " "	7' 0"	2
" " " " " " " "	6" × ½"	3' 0"	3
" " " " " " " "	" " " " " " " "	7' 0"	6
Linings for windows	6" × ¾"	5' 0"	8
" " " " " " " "	" " " " " " " "	7' 0"	2
Soffit boards for eaves	6" × ¾"	9' 0"	4
" " " " " " " "	" " " " " " " "	12' 0"	1
Forms for concrete lintels	9" × 1½"	10' 0"	4
" " " " " " " "	6" × 1½"	10' 0"	2
Struts for verandah posts	4½" × 3"	9' 0"	2

Name of part or material.	Number or quantity.	Description and dimensions.
Hard-burned bricks	2,500	For fireplaces, flues, etc.
Blue lime	50 bags	
Portland cement	7 "	
Shelving brackets	18 "	10" × 12" iron brackets with screws.
Stock doors	4 "	6' 8" × 2' 8" × 1½".
Stock sliding-sash windows	5 "	12 light, 10" × 12" panes.
Frames for outside doors	2 "	To suit 6' 8" × 2' 8" × 1½" doors.
Hinges for doors	12 "	4" × 1½" strong butt hinges.
Locks for doors	2 "	6" right-hand rim locks.
" " " " " " " "	2 "	6" left-hand " "
Air bricks " " " " " " " "	20 "	9" × 6"
Bar iron for dining-room grate	8 pieces	18" long × 1½" × ½".
" " " " " " " "	7 "	18" long × ¾" × ¾".
Bar iron verandah post anchors	8 "	15" long × 1½" × ½".
¾" bolts for " " " " " " " "	1 dozen	¾" dia. × 6" long, with nuts and washers.
Corrugated galvanised iron for roof	18 sheets	24 gauge, 9' long.
" " " " " " " "	38 "	" 8' "
" " " " " " " "	8 "	" 7' "
" " " " " " " "	8 "	" 6' "
Plain galvanised iron for flashings	1 sheet	6' × 3'.
Roof ridging	6 lengths	18" girth, 6' long.
Roofing screws	4 gross	2½" long, with lead and iron washers, galvanised.
Verandah connection screws	4 dozen	With nuts and washers.
Damp course, asphalted felt	100 feet	24" wide.
" " " " " " " "	70 "	6" "
" " " " " " " "	13 "	30" "
" " " " " " " "	12 "	18" "
Chimney cans	2 lengths	7" glazed earthenware pipe.
Nails	28 lbs.	4" wire.
" " " " " " " "	14 "	3" "
" " " " " " " "	7 "	2" "
" " " " " " " "	21 "	2½" flooring nails.
" " " " " " " "	10 "	1½" ceiling nails.

CHAPTER XXVII

SPECIFICATIONS

IN all cases in which buildings are to be erected by contract, it is necessary that the architect, or person responsible for the design and arrangement of the buildings, should specify in writing every detail. The resulting document is called the *specification*.

A written specification is necessary because it is impossible to show every detail of construction and arrangement on the drawings.

Specification and drawings, then, are supplementary to each other; they should be considered simultaneously, and that which is not shown or stated in the one should be found in the other, so that there may be no doubt as to the intention of the designer.

Both specification and drawings are signed by the contractor entrusted with the work, and then form a lasting and binding agreement between him and his employer. Any subsequent alterations, in either specification or drawings, which may be mutually agreed to by the contractor and his employer, should be initialled by the former in order to make them binding.

The contractor is supplied, free of charge, with one copy (usually a blue-print) of all working drawings, and also with a copy of the specification. Such detail drawings as are necessary for the execution of any part of the work may be supplied subsequently, upon the timeous request of the contractor. By "timeous request" is meant that the request should be made a reasonable time before it is necessary to execute the part of the work in question.

Arrangements for paying the contractor for work completed can be decided by agreement between contractor and architect or employer. As a rule, certificates are issued from time to time by the architect certifying that the contractor has satisfactorily carried out such and such work up to date. The contractor is then entitled to receive payment of at least a reasonable proportion of the amount due for such work.

If the building work is extensive the architect may appoint a clerk of works who acts as inspector, and is on the spot during the whole course of the work. The clerk of works, besides acting as inspector, also keeps records and diaries and reports periodically to the architect. He is entitled to have access at all times to any drawings or parts of the works.

In writing a specification certain preliminary and general clauses, with regard, for instance, to viewing the site, provision of water for the works, scaffolding, etc., are placed first. The remaining part of the document is divided into the various trades such as excavator, mason, concreter and bricklayer, carpenter, etc.

Each trade section of the specification may, where possible, be divided into two sub-sections, viz. (1) materials to be used, and (2) work to be done.

As an example of specification writing, a complete specification for the construction of a cow-byre and the drainage in connection therewith is appended.

The cow-byre in question is similar to that shown in Fig. 127, while a detail drawing of the stall divisions is given in Fig. 134. The part of the specification dealing with the drainage arrangements will be better understood on reference being made to the drawings relating thereto in Chapter XXV.

SPECIFICATION FOR COW BYRE

AT ———

GENERAL CONDITIONS

Materials and Workmanship.—The work is to be executed with materials of the best quality and in the most substantial manner, and the workmanship is to be the best of its kind.

Water for the Works.—The contractor shall provide for all water for the works at his own expense, and shall pay all charges levied by the owners and controllers of any water supply from which he may meet his requirements.

Materials on Site.—The contractor may, with the written approval of ———, be allowed to use in the works, free of charge, any clay, sand, gravel, stone, slate, or other building material found on the site, provided that the ground (if disturbed in procuring such materials) shall be made good, levelled up, or otherwise dealt with to the direction of ———.

View Site.—The contractor shall view the site of the buildings to be constructed, as no claim for extra work in connection with the siting of the building will be entertained.

Protection from Storms, etc.—The contractor must allow for protecting the works from all storms and surface and ground water, with all necessary drains, trenches, etc., and other requisite protection from inclement weather to the whole of the works.

Rubbish.—All superfluous earth or rubbish that may accumulate during the progress of the works, whether arising from the works included in this contract or otherwise, is to be carted away, and the whole of the premises left in a clean and perfect state at the completion of the contract.

Scaffolding.—The contractor shall provide, erect, and maintain, and finally clear away good and sufficient scaffolding for the use of all trades.

Cartage, etc.—The contractor shall provide all requisite cartage, carriage, tools, tackle, and every other matter required for the proper performance of the works.

Insurance.—As soon as the roof is on, the contractor shall insure the building against damage or destruction by fire, in an approved office, for the total amount of the contract price, and shall pay the first premium on the policy.

Completion of Works.—The contractor shall give possession of the completed works on the — day of — 19—. For every day over the said date during which the works are uncompleted the contractor shall pay the fine of £ — sterling per day, to the employer.

Maintenance.—The contractor will be required to make good, at his own expense, any defects, whether due to defective workmanship or materials, or to failure to observe any of the aforesaid covenants, which may appear within three months of the completion of the works.

EXCAVATOR

Clear Site.—Dig up and remove all rubbish and vegetable soil and substance from the whole area of the ground to be built upon, and roughly level same.

Excavation.—Excavate and level the ground under floors and outside the building to the extent and depths shown on drawings. Neatly trim the sloping faces of all cuttings.

Dig trenches for all foundations to the several lengths, widths, and

depths shown on drawings, or to such other depths as may be required to ensure a good foundation.

Perform all stepping to foundations where shown or required. Trim the sides of trenches the full width from top to bottom, and level and well ram the bottoms.

Drains, etc.—Excavate for all drains, surface water channels, gulleys, etc.

Water and other pipes to be not less than 1' 6" below the surface of the ground.

Filling.—Fill in and well ram with clean, hard, dry earth, filling to all foundations, floors, drains, etc., and make up levels, etc., with all necessary falls.

The upmaking under solid floors to be well watered and rammed, and thoroughly consolidated.

Surplus Earth.—All surplus earth and other material from the excavations is to be deposited and levelled on the site, or carted away as directed.

Water in Foundations.—No water is to be allowed to accumulate in any portion of the excavations or trenches.

The trenches and other excavations are to be protected against flooding, and any water entering them is to be immediately removed.

MASON

Foundation Walls (Footings).—Build all the foundation walls of the lengths, widths, and heights shown or figured on drawings, or of such extra depth where necessary to secure a firm foundation, in local stone as described, in roughly squared, uncoursed rubble, with all beds horizontal, and built without spalls, laid and flushed up in lime mortar, and levelled on top with stones in long lengths for damp proof course.

Damp Course.—Lay on all foundation walls a damp course as described (under "Concretor and Bricklayer"), the full thickness of walls above foundations, and without longitudinal joints. The damp course is to be laid level with the underside of solid floors, and continued up the vertical face of all steppings. It is to be stopped $\frac{3}{4}$ inch from external face of walls, and pointed in cement mortar.

At ends and angles the damp course must overlap the full thickness of walls, and at intermediate junctions the laps are to be 6 inches.

Facings and Pointings.—All exposed stonework is to be properly squared and hammer dressed, and to have the joints raked out 1 inch deep and pointed in 1 : 2 cement mortar, with a flat joint cut on both edges.

All salient angles are to be pitched true and plumb without chiselled margins.

CONCRETOR AND BRICKLAYER

Materials to be Used

Hard Core.—To be composed of broken granite, stone, brick, clinker, or other hard material.

Metal or Aggregate.—Metal for concrete to be well screened, coarse, clean gravel, or broken stone, and to be free from loam, clayey matter, and other impure mixtures.

That for concrete lintels to pass, all ways, through a 1-inch ring; and that for concrete floors to pass all ways through a 2-inch ring.

Sand.—Sand to be clean, coarse-grained drift sand of approved quality.

Lime.—Lime to be from an approved kiln, and of approved quality, and to be thoroughly burned.

Cement.—The cement shall be of an approved brand, and shall be capable of passing the tests specified by the "Engineering Standards Committee."

Cement Concrete for Floors.—Cement concrete for floors to be composed of one part Portland cement, three parts sand, and six parts metal as described for floors, mixed on a non-absorbent and clean platform, and proper measures are to be used, in proportioning, for holding the specific quantity of each material employed.

The materials are to be thoroughly well mixed by being turned over twice dry, and water added, and then turned over again until the whole is properly incorporated.

The water is to be added gradually through a fine rose, no more being used than is absolutely necessary to mix the whole thoroughly. The concrete, after mixing, is to be at once wheeled to the place where it is to be laid, and gently tipped from a height of not more than 2 feet into position, and carefully and steadily rammed.

Cement Concrete for Lintels.—Is to be composed of one part Portland

cement, to one part sand, to three parts metal as described for lintels, mixed as for floors.

Lime Mortar.—To be composed of one part lime to three parts sand well mixed together, with a sufficient quantity of clean water, on a non-absorbent platform.

Cement Mortar.—To be composed of one part of cement to three parts of sand, unless otherwise specified, well mixed together, with a sufficient quantity of clean water, on a non-absorbent platform.

To be mixed in small quantities, as no cement that has commenced to set will be allowed to be used.

Damp Course.—To be asphaltic felt sheeting of approved quality.

Bricks.—To be good, hard, sound, well-burnt local bricks, uniform in size, and the best procurable in the district.

Facing Bricks.—To be as above described, but specially picked for shape, size, and colour.

CONCRETOR AND BRICKLAYER

Work to be Done

Concrete Work Generally.—Special attention must be paid to the following points :—

- (1) The quality and mixing of the materials.
- (2) The depositing of the concrete in place, and thorough punning to ensure solidity and freedom from voids.
- (3) In all cases the concrete should be mixed in small quantities, sufficient for the particular section or area to be laid in one operation, which should be performed as quickly as possible.
- (4) Where work has to be recommenced on, or adjacent to, any previously laid surface, such adjacent surface is to be thoroughly wetted with clean water, or, if it has set hard, it must be hacked off, swept clean, and covered with cement grout.
- (5) The concrete, when laid, must be shielded against too rapid drying from exposure to the sun's rays or wind, and kept damp for at least fourteen days, with wet sacking.

- (6) All shaking and jarring must be avoided.

Hard Core.—Under concrete granolithic floor lay 6 inches of hard-core well-rammed, sloped, and stepped for manure channels.

Granolithic Floor.—The floor throughout the cow byre is to be laid to

proper falls and shaped, as shown on plan, for manger, stall, manure channel, and mid-passage.

Form and ram bed to within 1 inch of finished surface, and to a minimum thickness of $3\frac{1}{2}$ inches, with concrete as described for floors.

Float-up to within $\frac{1}{4}$ inch of finished surface with granolithic consisting of one part Portland cement, to three parts granite chips to pass through a $\frac{3}{4}$ -inch mesh and be retained on a $\frac{1}{4}$ -inch mesh.

Form finished surface with one part Portland cement to one part very fine granite chips.

The floating bed and finishing thickness are each to be laid before the previous layer has been allowed to set.

The granolithic work is to be carried out by experienced workmen, and is to be laid in panels, slightly V-jointed, and not exceeding 64 square feet in area. Thin strips of wood, or other suitable material, are to be laid between panels to break the contact.

Where granolithic is specified to be finished "red," the requisite quantity of red oxide of iron is to be used with the finishing thickness.

Line and groove floor of central passage, as shown on plan, with V-joint $\frac{3}{4}$ inch deep.

The floor is to be continued through door openings to form thresholds, and formed with a fair edge where necessary.

That edge of each manure channel which is next the cows' heels is to be only slightly rounded off, just enough to remove the sharp edge.

Bed in Stall Divisions.—Bed in vertical tubes of stall divisions, to a depth of 9 inches, where shown on plan, allowing a thickness of concrete of at least 3 inches below each vertical tube, and a thickness all round base of tube of at least 4 inches of concrete.

Granolithic Skirting.—The granolithic of the floor is to be turned 3 inches up those walls against which there is no manger, and rounded off on top.

Concrete Lintels.—Over openings for windows cast cement concrete lintels.

The lintels are to be not less than four courses of brickwork in depth, 12 inches longer than width of openings, and the full thickness of the walls, rebated as required for window frames.

Each lintel is to be reinforced by four fencing standards, weighing 3 lbs. per foot of length, as shown on drawing.

Brickwork.—The brickwork wherever practicable, and unless otherwise specified, is to be built in English bond and lime mortar.

No false headers are to be used, and none but whole bricks employed except where legitimately required to form bond.

The bricks are to be well soaked with water before being laid. The brickwork is to be thoroughly bedded and all joints flushed up solid throughout the whole width of each course.

All walls are to be carried up regularly so that, at no time during the course of construction, shall any part be more than 4 feet higher than adjoining parts.

Facing Bricks.—All exposed brickwork is to be faced with picked facing bricks as described.

Mortar Joints.—Mortar joints, in all brickwork, are not to exceed $\frac{3}{8}$ inch thick.

Build In.—Build in horizontal tubes of stall divisions, in positions shown on drawings, to a depth of 7 inches, in cement mortar.

Build in all fittings, door and window frames, ends of timbers, wood slips, hold-fasts, etc., in cement mortar. Build in all necessary wood slips and hoop-iron ties, for fixing woodwork as specified in "Carpenter."

Pointing.—The joints of both faces of walls are to be pointed with a flat, neat joint, as the work proceeds.

Bed and Point.—Bed and point all door and window frames, and bed and level all plates, in cement mortar.

Window Sills.—Build window sills, to window openings, of one course selected bricks on edge.

Lime White.—Twice lime-white the internal and external faces of all brick walls; and also all the roof timbers and roofing iron internally.

CARPENTER AND JOINER

Materials to be Used

Purpose-made Joinery.—All joinery is to be purpose made. No joinery is to be primed until it has been inspected and approved by —.

Timber.—The timber to be Baltic deal of good sound quality, thoroughly seasoned, and free from sap, large, loose, or dead knots, shakes, wany edges, or other defects.

The scantlings of all timbers to be sawn die square, and to hold full size when sawn.

Scarves, etc.—All wall-plates, ridges, hips, and purlins are to be in long lengths.

Scarves, etc., unless otherwise directed, to be 15 inches long, and, wherever practicable, placed at points of support.

Wrought Faces.—All exposed woodwork, unless otherwise specified, is to be wrought.

For each wrought face, $\frac{1}{16}$ inch will be allowed off specified sizes.

Defects.—Should the joints of any joiner's work open or give before the payment of the final amount, three months after possession of the completed works has been given, such defective joinery will have to be taken down and refitted and redecorated, or new joinery put in its place, at the contractor's expense.

Ironmongery, etc.—Nails, spikes, and bolts are to be best quality wrought iron.

All ironmongery is to be approved before fixing. Brass articles are to be fixed with brass screws.

All screws, bolts, spikes, nails, wrought-iron straps, etc., required for the proper completion of the work are to be supplied by the contractor.

Corrugated Iron.—The corrugated iron is to be 24 gauge galvanised iron of approved quality, secured with $2\frac{1}{2}$ " long galvanised iron screws, with galvanised iron and lead washers.

No iron affected by sea-water or otherwise damaged is to be used on the building.

CARPENTER AND JOINER

Work to be done

Centering.—Provide, fix, ease, and remove all necessary forms for manure channels, mangers, lintels, etc., with all necessary stays, blocks, wedges, etc.

Plates.—Roof plates to be $4\frac{1}{2}$ " by 3", scarved at joints and halved at angles, properly spiked together. All roof plates to be secured to walls with hoop iron bands lapped and spiked to plates, and built into walls ten courses deep; these bands to be about 5 feet apart.

Tarring.—All plates to be well coated with tar before fixing in building.

Roof.—The roof is to be constructed with 6" by $1\frac{1}{2}$ " double tie beams; 6" by $1\frac{1}{2}$ " rafters; 6" by $1\frac{1}{2}$ " double collar ties; 6" by $1\frac{1}{2}$ " king post;

6" by $1\frac{1}{2}$ " queen posts; and 6" by $1\frac{1}{2}$ " struts as shown in drawing. Trusses are to be spaced not more than 5 feet apart, and all members of roof securely bolted together with $\frac{1}{2}$ -inch wrought-iron bolts and nuts as shown.

Hip rafters are to be 9" by $1\frac{1}{2}$ "; and purlins, including hip purlins, 3" by $2\frac{1}{4}$ ". The ends of rafters are to be projected, shaped, and wrought, as shown, and where necessary 6" by $1\frac{1}{2}$ " sprockets (shaped and wrought) are to be provided to keep spacing equal.

Ventilator at ridge is to be constructed with 3" by 3" verticals and 3" by 2" longitudinals, as shown, all securely spiked together. Louvered ends are to be provided to the ridge ventilator as shown in drawings.

Corrugated Iron to Roof.—Cover roof throughout with 24 gauge galvanised corrugated iron as described, fixed with galvanised screws and double washers spaced not more than 12 inches apart horizontally. Perform all necessary bending and cutting as shown and required. Each sheet is to have a side lap of two corrugations, and an end lap of 9 inches.

Hips.—Cover all hips with 18" girth, galvanised iron ridging as described, lapped 9 inches at ends, close beaten into corrugations, and fixed with galvanised screws and double washers spaced not more than 12" apart.

Windows.—Construct the windows with $4\frac{1}{2}$ " by 3" deal, wrought, rebated, and arris rounded frames; with $4\frac{1}{2}$ " by 3" deal, wrought, twice rebated, and arris rounded mullions; and $4\frac{1}{2}$ " by 3" hardwood, wrought, rebated, check-throated, and sunk sill, grooved for water bar.

Sashes to be of $1\frac{3}{4}$ " deal, wrought, rebated, and arris rounded; divided for glazing as shown by $1\frac{1}{8}$ -inch wrought, rebated and arris rounded bars; with bottom rail rebated and splayed. Hang at bottom on a pair of stout 4" steel butt hinges, and fit with strong brass quadrant stay of approved pattern with opening gear complete.

Doors.—The doors to have $4\frac{1}{2}$ " by 3" deal, wrought, rebated, and arris rounded frames. The doors themselves to be 2" deal, wrought, framed, ledged, and braced; in two heights or leaves, with splayed meeting rail, hung to open outwards on a pair to each half or leaf of 2" by $\frac{1}{4}$ " by 24" wrought-iron hook and band hinges, bolted to door and frame with $\frac{3}{8}$ " wrought-iron bolts and nuts.

Fit each half or leaf with strong 12" locking bar and staple, with padlock and loose pin; and provide staple, and pin on chain, built into walling to hold doors back when open.

Dowels and Cramps.—All solid door frames are to be dowelled to thresholds with $\frac{3}{4}$ " wrought-iron dowels 5" long ($2\frac{1}{2}$ " in wood, $2\frac{1}{2}$ " in concrete); and to be secured to walls with 14 gauge galvanised hoop-iron cramps, $1\frac{1}{2}$ " wide, screwed to frames with two screws, and built 18" into walls, and turned up into brickwork joints; three cramps to each jamb.

Put similar cramps, two to each jamb, to windows.

Water Bar.—Provide and fix to each window 1" by $\frac{1}{8}$ " wrought-iron water bar, bedded $\frac{1}{2}$ " in groove in sill in thick white lead.

Cleaning Out, etc.—Clean out, from time to time, all shavings, cuttings, and other rubbish, from off the premises, during the progress of the works.

Before giving up possession, the contractor is to see that all doors, sashes, etc., work easily, and make all necessary adjustments, and leave the whole of the work complete, and to the satisfaction of —.

DRAIN LAYER

Materials to be Used

Pipes.—Pipes are to be best quality, salt-glazed, stoneware, socketed pipes, well burnt and glazed throughout, circular in section, straight, true in bore, and free from cracks and flaws of every description.

Sand and Cement.—As described in "Concretor and Bricklayer."

DRAIN LAYER

Work to be Done

Drain Pipes.—Lay 6" diameter salt-glazed drain pipes, as described, to a fall of not less than 1 in 50, accurately laid with joints butted closely and jointed with 1 : 1 cement mortar, and with 1 : 1 cement mortar fillet.

Special care is to be taken to sweep out the whole length of drain between manholes with a "badger" to insure that no cement or foreign matter remains in piping.

Properly connect up line of drain to liquid manure tank.

Inspection Chamber.—Construct inspection chamber, where shown on plan, with 6" cement concrete bottom projected 6" all round outside of walling; 9" walls in specially hard burnt bricks in cement mortar; and

6" cement concrete top, holed for, and fitted with, approved pattern heavy cast-iron single seal manhole cover and frame.

Provide and set half-section, white-glazed channel in bottom of inspection chamber, and deeply flaunch bottom in cement, as shown in drawing.

Render interior of inspection chamber to smooth and even surface with 1 to 2 cement plaster.

Size of inspection chamber internally 3' 0" by 2' 0" by 3' 0" deep. Depth approximate, and to be actually governed by the levels of ground.

Sumps.—Excavate for and construct No. 2 sumps, size 2' 0" $\times$ 2' 0", with bottom 1' 6" below centre line of drain pipe, with 4" cement concrete bottom, 9" brick walling in cement mortar and finished internally in cement plaster, and 4" cement concrete top holed for, and fitted with, single seal cast-iron covers and frames as described for inspection chamber.

Cleaning Eyes.—Where shown on plan, provide and fix easy bends brought up to ground level and fitted with plug bedded in bitumen, and above this set 15" by 15" by 14" slab of concrete with letters C. E. incised.

CHAPTER XXVIII

MISCELLANEOUS NOTES :—COOLNESS IN BUILDINGS—A COOL-STORAGE ROOM
—PROTECTION OF BUILDINGS FROM LIGHTNING—WHITE ANTS AND
BUILDINGS

COOLNESS IN BUILDINGS

IN the case of iron-roofed buildings with ceilings of small-fluted sheet iron, Mr. C. E. Owen Smyth, Superintendent of Public Buildings, South Australia, recommends that, if the building is near the sea-coast, a thick layer of dry seaweed should be laid on sheets of paper on top of the ceiling, *i.e.* between ceiling and roof.

If the building is distant from the coast, the farmer should make wood charcoal, and deposit a layer of that material, 6 inches thick, on top of the ceiling.

Either of the above will be found to be a good heat-insulator, preventing excessive range of temperature variation inside of the building.

COOL-STORAGE ROOM

Mr. E. A. Ryland, Dairy Supervisor, Victoria, Australia, describes a canvas room, a number of which have been constructed in Australia.

A light wooden frame-work is constructed 6 feet square by 6' 6" in height, with sloping hip-rafters on top to form a square roof. This frame-work is covered with canvas or Hessian cloth down to 9 inches above the (pine) floor. The lower 9 inches is occupied by a fly-proof perflation panel of fly-netting. From the peak of the roof, a vertical ventilating pipe takes off, capped by a cowl. This pipe is about 6 feet long so as to induce a good draught. A framed door, covered with canvas, is provided in one side of the room.

Water is distributed over the roof and walls by perforated lead piping. Surplus water is caught in rain-water guttering, which extends round the walls immediately above the perflation panel, and thence is led away.

The temperature of the room is lowered, and kept low, by continuous evaporation of some of the moisture in the walls and roof.

The principle of evaporation for cooling purposes is not new, canvas water-bags being familiar to all. This principle has also been applied to household cupboards, built with canvas or Hessian walls, and supplied with water from a paraffin tin standing on top.

Around one such room, built in Australia, a frame-work carrying wire netting, over which creeping plants can be trained, was erected a foot or two away from the canvas walls and ceiling. The water is supplied from a tank filled by a wind-mill, the surplus water which drains away from the canvas roof and walls being used for irrigation purposes in an adjoining garden.

PROTECTION OF BUILDINGS FROM LIGHTNING

The absolute protection from lightning of a corrugated iron building is simple and inexpensive. All that is necessary is to insure good metallic connection between the roofing iron and the iron of the walls, and either to carry the iron sheets of the walls into the ground for 2 or 3 inches, or to provide a number of iron strips having their upper ends metallically connected to the corrugated iron of the walls, and their lower ends buried in the ground to a depth of at least one foot. Such iron strips might be situated at each corner of the building and also, if the size of the building calls for it, in intermediate positions such that adjacent strips are not more than 30 feet apart.

In the case of a stone, brick, or wooden building with an iron roof; if rain-water guttering and down-pipes are provided, the former should be joined by metal to the corrugated iron of the roof at frequent intervals, and the latter should have their lower ends electrically connected to the earth by strips of iron metallically connected to the down-pipes and having their lower ends extending at least one foot into the ground. If no rain-water guttering and down-pipes are provided, the iron of the roof should be connected with the ground by strips of iron, which should be as straight as possible. For dwelling-houses of ordinary size, one iron strip at each corner of the building will be sufficient.

Buildings with thatched roofs can be protected by numerous barbed wires metallically connected to the galvanised iron ridge capping of the roof, carried down the sides and ends of the building (simply lying on

the thatch) and having their ends buried in the ground. The object to be aimed at is the enclosure of the building in a system of wire-work—a contrivance in fact of the nature of a bird-cage—well connected to earth.

WHITE ANTS (TERMITES) AND BUILDINGS

Preparation of Building Sites.—If possible, buildings should be erected on sites which are free from ant nests or channels. If, however, a building must be erected on ant-infested ground, the nests should be eradicated by the use of the well-known “Universal Ant Exterminator,” or similar apparatus, consisting of a pump connected with a fire-box and pipe, the end of the last mentioned being inserted into the ant hole. The powder used consists of:—

White arsenic (finely powdered) 3 parts by weight, flowers of sulphur 1 part by weight. This is ignited in the fire-box, and the resulting fumes are pumped into the ant-workings by means of the attached pump.

It is necessary to treat a much wider area than that actually to be built upon, because some species of termites drive their galleries far out from the nests. It is desirable to pump the fumes into a live gallery or opening, *i.e.* one actually in use by the termites. The pump can be used to great advantage when flying termites are seen escaping from well-defined holes in the ground, these holes being in communication with the whole arterial system of the nest. The fumes should be pumped into them at once; to mark the spot and come back a few days later for the purpose of injecting fumes is useless, because the termites block up these outlets and cut them off from the nest immediately after they have served their purpose of allowing the winged insects to escape.

Structural Arrangements to circumvent Attack by Termites.—Only a few rational points need be borne in mind, in order to design and build a house which will be resistant to attack by termites. The precautions taken against termites will also prevent attack by dry rot.

The footings should be built high enough to provide clearance of 2 or 3 feet between the ground and the floor joists, and many large ventilators should be provided in the footings so as to permit of the free entrance of light and air to all parts beneath the floors. Concrete floors, such as those of kitchens, bathrooms, or verandahs, and also hearths for fireplaces, should not be constructed upon soil or building

debris which has been filled in between the supporting brick or stone walls. Such floors may consist of reinforced slabs with their ends resting on the supporting walls, and spanning the spaces between the latter, which spaces should be left empty. Internal supporting walls below floors should have frequent openings in them to allow free circulation of air and admission of light to *all* parts under the floors, including concrete floors, floors of verandahs, and hearthstones. Footings, and internal walls for the support of floors, should be built of stone or hard-burned bricks in cement mortar; building in *dagga* and merely pointing with cement mortar is insufficient. If *dagga* is to be used at all, either between the bricks or as a plaster, it should be confined to the walls proper, *i.e.* above the footings, and the latter should be surmounted by a continuous sheet-metal damp course. The edge of this metal course, on the inner side of the walls, should project or overhang a few inches beyond the vertical face of the footing, and should be bent slightly downwards.

It is a good plan to provide some means of access, when possible, to the space below the floors, so that a person can enter for purposes of investigation, etc.

Wood which is to occupy positions where it will be liable to attack, such as floor-plates, sleepers, flooring-joists, and the under-side of flooring boards, may be treated by soaking it for 24 hours in a solution of arsenite of soda or copper sulphate, 1 lb. to the gallon, or in arsenical cattle dip for a week or longer. The cattle dipping-tank, if present, may be utilized for this purpose. The timbers in question—except, of course, the upper sides of the flooring boards—may then be tarred in the usual way, after the timber has become dry.

Creosoted wood also resists attack by termites.

It may also be mentioned that a solution of corrosive sublimate, 6 ozs. to the gallon, as used to prevent dry rot, is effective in protecting the timber from termite attack. This poison, added to the paste, will protect wall-paper.

The same general principles should be observed in the construction of wood-and-iron houses, *i.e.* the building should be raised well off the ground on either footings or piers of stone or hard-burned brick built in cement mortar, or on piles of ant-resistant timber such as jarrah. If brick, stone, or termite-proof woods are unavailable, then the wood employed should be soaked for some days in arsenic solution and, when dry, well tarred or creosoted before being implanted in the ground.

As a further precaution the lower ends of the piles may be imbedded in cement concrete blocks, so that each pile is insulated from the soil to the extent of several inches by concrete all around and below, besides which the concrete block should project several inches above the ground surface. Similar precautions must be taken to insulate steps leading to either verandahs or doors.

Sometimes the lower ends of fencing posts, which are to be sunk into the ground, are charred, but this precaution is futile against termites unless the charred area extends well above ground level.

A device which has been used in South Africa, consists of depositing a fairly thick layer of cinders and ashes under the floors of the house to be protected, and dressing the surface with tar. This artifice might be employed, as an extra precaution, in connection with houses built on the termite-resistant lines just discussed.

Another palliative measure is the distribution of poisoned material under the floors of the house to be treated. This material may consist of pieces of old sacking moistened with arsenite of soda dissolved in a small quantity of hot water, to which treacle or sugar is added.

Treatment of Infested Timber.—For the treatment of partly eaten timber such as flooring, skirting boards, etc., a solution of arsenic in some mineral oil can be recommended. This forms the basis of many preparations for the purpose on the market.

The pouring into crevices, etc., in which termites may be doing damage, of carbolic oil, benzine, paraffin oil, and various cattle dips, can be adopted as a palliative measure; a mixture of arsenic and syrup may be placed in such galleries as can be exposed.

Timber, used to replace that which has been removed because of termite attack, should always be soaked, as already described, in a solution of arsenite of soda in water.

Much of the preceding information has been derived from a pamphlet entitled "White Ants in Natal," by Mr. Claude Fuller, Assistant Chief of the Entomological Division, and from other publications of that Division.

APPENDIX I

CALCULATION OF HORIZONTAL REINFORCING BARS (HOOPS) IN WALL OF SILO

THE silo (Fig. 166) is 15 feet diameter by 30 feet high, internally.

For a depth of silage of 30 feet, the pressure on the silo wall at the bottom is 330 lbs. per sq. ft.

Considering a section of the wall 1 foot high at the bottom of the silo, the bursting pressure which is resisted by the sections pq and rs (Fig. 215) $= 330 \times 15$, the internal diameter of the silo being 15 feet. We design so that the reinforcement alone will be strong enough to take this stress with safety, *i.e.* we neglect the tensile strength of the concrete. The above bursting pressure is divided equally between the two sections pq and rs .

$\therefore$ Total stress on section pq (or rs)

$$= \frac{330 \times 15}{2} = 2475 \text{ lbs.}$$

Allowing a safe stress in the iron of 12,000 lbs. per sq. in., and denoting the cross-sectional area of iron in the lowest foot of the silo wall by A sq. ins., we have—

$$12,000 A = 2475$$

$$A = \frac{2475}{12,000}$$

$$A = 0.206 \text{ sq. in.}$$

Now the cross-sectional area of a $\frac{3}{8}$ " round bar is 0.11 sq. in., hence two $\frac{3}{8}$ " dia. bars, in the lowest foot of height of the wall, will be sufficient; *i.e.* the horizontal reinforcement at the foot of the silo wall should consist of $\frac{3}{8}$ " dia. bars (hoops), spaced 6" apart vertically from centre to centre.

Theoretically the $\frac{3}{8}$ " reinforcing bars may be spaced further apart, the nearer they are situated to the top of the silo. Thus at mid-height these horizontal

FIG. 215.

bars may be spaced twice as far apart as at the bottom, *i.e.* 12" apart, while at $\frac{3}{4}$ height they may be four times as far apart or 24" from centre to centre. For practical reasons, however, they are kept closer together, as shown in Fig. 166.

The vertical bars in the wall may be looked upon as stress distribution rods, inserted for the purpose of transmitting the stresses in the concrete to the horizontal hoops; they should be inside the hoops.

DESIGN OF REINFORCED CONCRETE TANK OR RESERVOIR (Figs. 179-184).

Each wall of the tank consists of a slab supported at intermediate points by the piers, and at the ends by two of the other walls. The slab may be considered to be continuous, like a continuous beam. We will first consider a strip of the slab, 1 foot in height, at the bottom of the tank. Fig. 216 is a cross section of this strip under consideration.

By Hooke's law—

FIG. 216.

$$\frac{\text{stress}}{\text{strain}} = E \quad \dots \quad (I.)$$

Let f_c denote the safe compressive stress in the concrete = 500 lbs. per sq. in.

f_t denote the safe tensile stress in the steel = 16,000 lbs. per sq. in.

E_c denote the modulus of elasticity for concrete.

E_t denote the modulus of elasticity for steel.

Then $\frac{E_t}{E_c}$ may be taken = 15.

From equation I., $\text{strain} = \frac{\text{stress}}{E}$;

for the concrete, $\text{strain}_c = \frac{f_c}{E_c}$

for the steel, $\text{strain}_t = \frac{f_t}{E_t}$

$$\therefore \frac{\text{strain}_c}{\text{strain}_t} = \frac{f_c/E_c}{f_t/E_t} = \frac{f_c}{f_t} \cdot \frac{E_t}{E_c} \quad \dots \quad (II.)$$

But strain is proportional to distance from the neutral axis, hence—

$$\frac{\text{strain}_c}{\text{strain}_t} = \frac{h}{d - h} \quad (\text{see Fig. 216}) \quad \dots \quad (III.)$$

Therefore, equating II. and III.—

[illegible]

We will design for a bending moment, M , for a continuous beam, of $\frac{wl^2}{10}$ where

l = the distance between the piers = 8 feet,
 w = the water pressure in lbs. per sq. ft. at the bottom of the tank, supposing
 the tank to be filled to the full depth of 5 feet, $= 62.5 \times 5 = 312.5$ lbs.
 per sq. ft. We consider this pressure to act over a horizontal strip,
 1 foot high, at the bottom of the wall, then—

$$\begin{aligned} M &= \frac{w l^2}{10} = \frac{312.5 \times 8 \times 8}{10} \text{ foot-lbs.} \\ M &= \frac{312.5 \times 8 \times 8 \times 12}{10} \text{ inch-lbs.} \\ M &= 24,000 \text{ inch-lbs.} \end{aligned}$$

Now M = the moment of resistance of the section, therefore,
referring to Fig. 216—

[illegible]

$$M = \left(\frac{500}{2} \times 12h \right) \left(d - \frac{h}{3} \right)$$

since

$b = 12$ inches.

$$M = 3000h\left(d - \frac{h}{3}\right)$$

$$M = 3000hd - 1000h^2.$$

Substituting for h from IV. we have—

$$\begin{aligned} M &= (3000 \times \frac{15}{47})d^2 - 1000(\frac{15}{47})^2 d^2 \\ M &= 957.4d^2 - 101.9d^2 \\ M &= 855.5d^2 \\ d^2 &= \frac{24,000}{855.5} \end{aligned}$$

hence

$d = 5.3$ inches.

Allowing a depth of imbedment of the steel in the concrete of $1\frac{3}{4}$ inches

from the centre of the tension rods to the tension surface of the concrete, then the thickness of the tank wall at the bottom

$$= 5.3 + 1.75$$

$$= 7 \text{ inches approximately.}$$

We next proceed to calculate the horizontal reinforcement.

$$\text{The total pull in the steel} = f_t \cdot a$$

but

$$\text{total pull in steel} = \text{total thrust in concrete}$$

$$f_t \cdot a = \frac{f_c}{2} \times bh$$

$$f_t \cdot a = \frac{500}{2} \times 12h$$

but from IV.,

$$h = \frac{15}{47}d$$

$$h = \frac{15}{47} \times 5.3$$

$$\therefore f_t \cdot a = \frac{500}{2} \times 12 \times \frac{15}{47} \times 5.3$$

$$16,000 a = \frac{500 \times 12 \times 15 \times 5.3}{2 \times 47}$$

$$a = \frac{500 \times 12 \times 15 \times 5.3}{2 \times 47 \times 16,000}$$

$$a = 0.317 \text{ sq. in.}$$

i.e. the cross-sectional area of horizontal reinforcement in 1 foot height of the wall at the bottom = 0.317 sq. in.

Let us try $\frac{1}{2}$ " dia. round bars. The cross-sectional area of a half-inch bar = 0.1963 sq. in., and we require to provide a cross-sectional area of 0.317 sq. in. to the foot of height, therefore 0.1963 sq. inch is sufficient for—

$$12 \times \frac{0.1963}{0.317} = 7.44 \text{ inches,}$$

or say $7\frac{1}{2}$ inches. Therefore horizontal $\frac{1}{2}$ " dia. rods, at the bottom of the wall, should be spaced $7\frac{1}{2}$ " apart vertically from centre to centre.

Calculating similarly for a value of $w = \frac{312.5}{2}$ lbs. per sq. ft., we find that the thickness of the wall at mid-height, *i.e.* $2\frac{1}{2}$ feet above the bottom of the tank, = $5\frac{1}{2}$ ".

If the faces of the wall be straight this will make the thickness of the wall at the top = 4 inches.

The spacing of the half-inch diameter horizontal rods, at mid-height of the wall, works out to $10\frac{1}{2}$ inches; therefore the $9\frac{1}{4}$ -inch spacing shown in the drawings will be quite safe.

The piers are next calculated. Each pier is assumed to take the pressure of water on a surface extending 4 feet on each side of it (the piers being 8 feet apart). The area of this surface for 5 feet depth of water = $8 \times 5 = 40$ sq. ft.

The pressure per square foot at the bottom of the tank = 312.5 lbs., therefore

the average pressure on the 40 sq. ft. of area = $\frac{312.5}{2}$ lbs. per sq. ft., hence the total horizontal pressure taken by a pier

$$= \frac{312.5}{2} \times 40 = 6250 \text{ lbs.}$$

The resultant pressure acts at a height of $\frac{1}{3}$ of the depth of water, or $\frac{5}{3}$ feet, above the bottom of the tank, therefore bending moment on buttress at foot

$$= M_b = (6250 \times \frac{5}{3}) \text{ foot-lbs.}$$

or

$$M_b = (6250 \times \frac{5}{3} \times 12) \text{ inch-lbs.}$$

Assuming the thickness of the buttress to be 6 inches, *i.e.* $b = 6$, then from equation V.—

$$M_b = \left(\frac{500}{2} \times 6h \right) \left(d - \frac{h}{3} \right)$$

$$M_b = 1500hd - 500h^2$$

substituting for h from IV. we have—

$$M_b = 1500 \times \frac{15}{47}d^2 - 500 \times \left(\frac{15}{47} \right)^2 d^2$$

$$M_b = 479d^2 - 50.9d^2$$

$$M_b = 428.1d^2$$

$$\therefore d^2 = \frac{6250 \times 5 \times 12}{3 \times 428.1}$$

hence $d = 17.1$ inches, and allowing for a depth of imbedment of the steel in the concrete of $1\frac{3}{4}$ inches from the centre of the tension rods to the tension surface of the concrete, depth of buttress at bottom = $17.1 + 1.75$
 = 18.85 inches.

We next proceed to calculate the vertical reinforcement.

The total pull in the steel = the total thrust in the concrete

$$f_t \cdot a = \frac{f_c}{2} \cdot bh$$

$$= \frac{500}{2} \times 6h$$

but from IV.,

$$h = \frac{15}{47}d$$

$$h = \frac{15}{47} \times 17.1$$

$$\therefore f_t \cdot a = \frac{500}{2} \times 6 \times \frac{15}{47} \times 17.1$$

$$a = \frac{500 \times 6 \times 15 \times 17.1}{2 \times 16,000 \times 47}$$

$$a = 0.512 \text{ sq. in.}$$

Now the cross-sectional area of a $\frac{9}{16}$ " round bar is 0.249 sq. in., therefore the cross-sectional area of two such bars = 0.498 sq. in. This seems barely sufficient, but two $\frac{9}{16}$ " dia. bars will be strong enough, when we consider the extra strength gained through turning these two bars by a gentle curve into the base.

As in the silo, the vertical rods, other than those in the buttresses, shown in the drawings, may be regarded as stress distribution bars ; any extra strength due to them will increase the factor of safety of the structure.

CALCULATION OF GRADUATIONS SHOWING VOLUME OF LIQUID IN A
CATTLE DIPPING TANK AT VARIOUS DEPTHS.

Let the whole volume of liquid at any depth be denoted by V ;

Let the volume of liquid in the swim at that depth be denoted by v ;

Let the volume of liquid in the outslope at that depth be denoted by v_1 ;

then

$$V = v + v_1$$

Referring to Fig. 217—

$$\delta v = y l \delta x$$

and

$$\delta v_1 = yq\delta x$$

$$\therefore \delta V = y(l + q)\delta x \quad . \quad . \quad e \quad , \quad \eta \quad \frac{r}{\rho} \quad , \quad . \quad (I.)$$

Considering the similar triangles abc and dec , we have—

$$\frac{de}{ec} = \frac{ab}{bc}$$

but

$ab = 1$ foot,

$$de = \frac{y - 2}{2} \text{ feet,}$$

$bc = 6$ feet,

and

$ec = x$ feet.

Hence

$$\frac{y-2}{2x} = \frac{1}{6}$$

$$\therefore y - 2 = \frac{x}{3}$$

$$y = \frac{x}{3} + 2$$

also

$$\frac{x}{q} = \frac{6}{15.2}$$

$$\therefore Q = \frac{15.2x}{6} = \frac{7.6x}{3}$$

and

$l = 23.75$ (see Fig. 217).

Substituting these values for y , q , and l in I., we get—

$$\delta V = \left(\frac{x}{3} + 2\right) \left(23.75 + \frac{7.6x}{3}\right) \delta x$$

$$\delta V = (0.844x^2 + 12.984x + 47.5)\delta x$$

$$V = \int (0.844x^2 + 12.984x + 47.5) dx$$

$$V = \frac{0.844x^3}{3} + \frac{12.984x^2}{2} + 47.5x$$

there being no constant of integration, because when $x = 0$, $V = 0$.

$$V = 0.2813x^3 + 6.492x^2 + 47.5x$$

when

$$x = 2$$

$$V = \{0.2813 \times (2)^3\} + \{6.492 \times (2)^2\} + \{47.5 \times 2\}$$

$$V = 123.22.$$

FIG. 217.

Similarly, calculating the value of V for various values of x ranging from 0 to 6, we have—

Value of x in feet.	Corresponding value of V in cubic feet.	Corresponding value of V in gallons.
0	0	0
1	54.27	339.21
2	123.22	770.11
3	203.52	1303.27
4	311.87	1950.22
5	431.96	2718.52
6	579.47	3621.70

On plotting this table, values of V in gallons against values of x in feet, we obtain the graph shown in Fig. 218; from which the graduations are got as indicated in the figure. For instance, to find, say, the 2000 gallon graduation mark. From the point 2000, on the horizontal base line of the graph, erect a perpendicular to cut the curve or graph. The point in which the perpendicular

in question cuts the curve is distant $4' 0\frac{3}{4}"$ (to scale) from the base line, hence the graduation mark, 2000 gallons, should be scribed on the wall of the tank

FIG. 218.

at a height of $4' 0\frac{3}{4}"$, above the bottom of the tank, measured *vertically*. Similarly the positions of the other graduation marks may be determined.

APPENDIX II

THATCHING ON THE FARM

PRINCIPLES AND PRACTICE DESCRIBED ; TIMBERING, MATERIALS AND METHODS

THATCH as a roof-covering is quite unsuitable for use in cities and towns, indeed it is usually prohibited by municipal authorities on account of the risk of fire. For rural districts, however, it is more suitable, not only for cheap sheds, etc., but also for dwelling-houses.

If the use of thatch as a roof-covering is contemplated, its advantages and disadvantages should be weighed.

Advantages.—As advantages it may be mentioned that it is light and is also a good heat insulator, rendering the building which it covers cool in summer and warm in winter. Coolness in summer is of particular importance in the case of dairies, for which thatch, used in conjunction with hollow or cavity brick walls, gives good results.

Thatch is also cheap when good thatching material is used, but it is false economy to use poor thatching-grass for anything but work of a purely temporary nature. When well laid and kept in repair, thatch is rarely penetrated by rain.

Disadvantages.—Probably the greatest objection that can be urged against thatch is that it increases the risk of fire. This is reflected in the premiums charged by fire insurance companies, who impose premiums on thatched buildings which are about three times as high as those on buildings roofed with tiles or slates.

The problem of rendering thatch fire-resisting has led to considerable discussion. One method is to soak the dry grass in a solution of alum in the proportion of not less than 1 lb. of alum to eight gallons of water. The grass should be allowed to soak in the solution for from one to one and a half hours. A long drinking trough is useful for the purpose. While the grass is being dried the drips of alum solution may be caught for further use.

Another method is to soak the grass in lime water.

Another objection to thatch is that it forms a harborage for vermin and small birds, and, if used for a cow-byre or other building housing live stock, cannot be effectively disinfected after an outbreak of infectious disease among the animals.

Thatch is also liable to be stripped off by high winds, and it is not easy to attach effective eave gutterings.

Practice in Great Britain.—The following notes on British practice cannot but be of interest. In Great Britain the materials generally employed are wheaten straw, rye straw, and reeds; while in Scotland heather and broom are also used. Well-grown, stiff, wheat straw answers for all general purposes, but the lasting qualities of rye straw and reeds are superior. Heather is used mostly for ornamental thatching, *e.g.* for model dairies, cricket pavilions, and summer houses.

Oat and barley straw are only suitable for thatching ricks, where the corn to be covered has not to remain in the rick for any considerable length of time. The "Encyclopædia Britannica" states that wheat straw lasts from fifteen to twenty years, oat straw about eight years.

The straw used is not passed through a threshing machine, which breaks it, but is hand-threshed by flail. It is damped before use, made up into bundles, beaten to knock out flag, etc., and well raked with a haymaker's rake to remove all loose, short or twisted straw.

The bundles are sewn to the thatching laths by tarred string, the butt ends of the straw pointing down the roof-slope. Each row of bundles, when laid, is overlapped by the succeeding row further up the roof-slope, to such an extent as to cover the binding string. The thatch is laid from 9 to 16 inches thick, and in well-finished thatching only the butt ends of the straw are visible from the outer side of the roof-slope. Thatching poles (purlins) of rough fir, ash, larch, or hazel are used, spaced up to 12 inches apart. Rough, round poles are better than square sawn thatching laths in one respect, *viz.*, that the lacing string can be pulled tighter around them, even though the corners of the latter be rounded off.

The work of laying the bundles of straw ("staples") is commenced at the eaves and carried upwards till the ridge is reached. At the ridge a layer of good, firm, fibrous turfs is placed on top of the straw in order to form a bolster, or well-defined ridge. An alternative ridge is sometimes used, formed of two boards fixed to overlap the thatch for some distance on each roof-slope.

When the roof is otherwise completed it is raked down and longitudinal runners or bands of hazelwood or twined straw are pegged to the thatch covering, with hazel spikes, near the eaves and ridge and sometimes also intermediately (see Fig. 219). These "runners," or "lacings," tend to prevent stripping of the roof-covering in high winds, and also add considerably to its beauty.

Valleys are smoothly rounded in with an extra thickness of thatch, no valley guttering being employed.

Eaves guttering, consisting of a wooden trough bracketed from the wall, is often used to catch the drip from the thatch, the eaves being trimmed horizontally with shears at completion.

FIG. 219.

Practice in South Africa.—Tambookie grass ranks high as a suitable thatching material in South Africa, being tough and lasting. Grass that is to be used for thatching should be cut before it becomes over ripe and dry, say at about the same stage as that at which the hay is usually cut. Reeds are also used extensively, especially for under-thatching, and rye straw can be employed.

The thatching-grass is made up in bundles of a size in accordance with the

FIG. 220.

thickness of thatch covering to be laid. A common size is such as can be ringed by the fingers and thumbs of both hands placed tip to tip; in this country thatch is generally laid from 4 to 6 inches thick only. Each bundle is combed

by drawing it over a haymaker's rake or specially made comb. This gets rid of short, loose, and twisted grass. A comb may be made for the purpose by boring holes through a 1-inch thick piece of wood, and driving 6-inch wire nails through these holes, which should be just large enough to allow the nails to be driven through them without splitting the wood. This comb can be fixed rigidly at a suitable height, and the bundles drawn across it. Each bundle should be "butted" by dumping it down on a flat surface, to bring all the butt ends of the grass in line with each other. The bundle is then bound with string. The bundles should be uniform in size.

In thatched roofs the rafters are generally from 2 ft. to 2 ft. 6 ins. apart, and are crossed by $1\frac{3}{8}$ -in. by $1\frac{3}{8}$ -in. thatching laths with corners rounded off. Or, for the latter purpose, round, rough poles about $1\frac{1}{2}$ -in. diameter may be used. The thatching laths or poles are spaced 12 inches apart from centre to centre (see Fig. 220), and to them the bundles of grass are tied or laced with tarred string, about $\frac{3}{16}$ -in. thick.

Method.—Three men are required, viz., an upper thatcher, an under thatcher, and a man to pass the bundles up to the upper thatcher. For sewing or stitching the bundles to the thatching laths, a straight wooden needle about 12 inches long is required. Thatching is commenced at the eaves, the bundles

FIG. 221.

being laid very close together and sewn on row by row till the ridge is reached. As already mentioned, tarred string is employed for this purpose, and each row of grass should cover the twine of the bundles of the next lower row (see Fig. 221). The under thatcher fastens the twine to the thatching lath at the commencement, passes the needle through the thatch to the upper thatcher, who

passes it round the bundle (the string with which the bundle was originally tied being removed), and pushes it through to the under thatcher again.

The latter then passes the needle round the thatching lath and out again, through the thatch, to the upper thatcher. This process is repeated as often as necessary. Every time the under thatcher pulls the string through he should tug, while the upper thatcher simultaneously thumps the grass at the place where the stitch is being made; or some similar method should be adopted in order to get tight stitches.

When the second layer of grass is fastened, the thatchers proceed to even off the roof. As shown in Fig. 221, the roof surface is stepped. To remove these steps a board with a serrated face and a handle on the back (Fig. 222)—or a leather strap on the back (Fig. 223)—is used. By means of such boards the grass is pushed up till the surface of the roof coincides with the line AB (Fig. 221).

FIG. 222.

FIG. 223.

This process is carried out after each two layers of bundles are tied on, not after the whole roof-slope is completely thatched.

The lower layers may be fixed by the upper thatcher standing on a ladder. Afterwards, when he is working higher up the roof-slope, he may use as a foot-rest a pole or board lying on the completed thatching, and slung from the rafters higher up by ropes at each end.

As the ridge of the roof is approached shorter bundles are used. The tips of the highest row of bundles are bent over the roof ridge and tied to the highest lath of the other roof-slope.

The ridge capping may consist of galvanised iron sheets. These sheets should have a line of holes punched about 2 inches in from each edge, through which a galvanised iron wire is passed to lace the capping to the purlins. The holes should be no larger than required, and soldered after the wire is in position; the same remarks apply to flashings, which will be discussed later.

Reed Sub-Stratum.—A 1-inch layer of reeds below the grass thatching is of advantage, especially in the case of buildings without ceilings, as it prevents short, broken pieces of grass from falling into the room below. Most of this, however, should have been previously removed by combing the bundles. The reeds may be secured as follows: Above a purlin or thatching lath about every 3 feet, according to the length of the reeds, a line of thick galvanised wire is laid horizontally along the roof. This wire is pulled down tightly on top of the reeds by thinner wires which are looped to it, and have their ends passed through

the layer of reeds and tied to the thatching lath below. These thin wires should be attached at every foot distance along the thick outer wire. The wires are covered by the grass thatching on top, which is put on as before described, the tarred string lacing the bundles to the thatching laths being simply passed through the layer of reeds where required.

MAKING THE ROOF WATERTIGHT; FIXING THE FLASHINGS

Where the roof-covering meets a vertical wall, special provision must be made to prevent leakage. This is usually done by the provision of "flashings"; for instance, where a chimney shaft penetrates the roof-covering, and at gables.

The flashings for a chimney shaft are illustrated by Fig. 224, where H.F. is called a horizontal flashing and S.F. a side flashing.

FIG. 224.

The upper edge of the flashing is bent over to the extent of about 1 inch, which part is inserted and wedged into the joint between the bricks. The lower edge is turned over for at least 6 inches; this part rests on top of the thatch and is laced with galvanised wire to the purlins below, just as was explained for the roof capping, the holes being no larger than necessary and soldered up after the wire is in position, and all is complete.

The side flashing, S.F., consists of an "under-flashing," with one edge bent up against the chimney shaft and overlapped by the upper-flashing or "apron" (see also Fig. 229). The apron consists of short pieces with their upper edges bent over, about 1 inch, and let into (or "ragged" into) the joints between the bricks. Each short piece overlaps the next one further down the roof-slope, and also the under-flashing, by from 2 to 4 inches. Edges such as XX (Fig. 224)

are not vertical, but overhang in order the better to exclude rain. The tail of each apron piece is held in a slit cut in the adjoining piece, as shown at A in the figure. A little solder is required at B, at each corner, where there is no overlap.

The upper horizontal flashing must be overlain, to prevent leakage. In Fig. 225 it is overlain by the galvanised iron roof capping.

Where the chimney shaft is further down the roof-slope (Fig. 225), the upper horizontal flashing must be covered by a galvanised iron sheet, having its upper

FIG. 225.

edge tucked under the roof capping as shown. This sheet lies on top of the thatch.

Where the chimney is still further down the roof-slope, the upper horizontal flashing may be extended well up the roof-slope, and the thatch thickened and dressed over it, as shown in Fig. 226.

To minimise danger of fire, chimney shafts should be carried well above the roof-slope, and their walls should not be less than 9 inches thick.

In place of metal flashings, an "oversailing" or projecting ledge of first-class tile is sometimes formed round the chimney shaft, just above the surface of the finished thatch. Gables may be similarly treated, or may have metal flashings. From the point of view of appearance, however, a tile oversailing is superior.

FIG. 226.

Gables.—The treatment of the gable in Dutch architecture is well known. A Dutch gable ("Hollandse gevel") is illustrated in Fig. 227, but may have

FIG. 227.—Hollandse Gevel.

different forms according to the artistic feelings of the architect.

Where it is desired to carry the thatch over the gable wall, the verges may be

finished by a barge-board spiked to the ends of the thatching laths (Fig. 228), and stayed by wires running obliquely from barge-board to thatching laths.

FIG. 228.

Fig. 229 illustrates the arrangement of the thatch against a gable, and shows the under-flashing and apron flashing.

FIG. 229.

The finishing of the eaves and the attachment of the guttering are indicated in Fig. 220. The thatch along the eaves should be trimmed off either horizontally, or even with its under face sloping slightly downwards towards the guttering. Wide guttering should be employed; 6-in. ogee guttering has been shown, but still wider guttering made up of boards, lined with galvanised iron, and supported from the walls by brackets, is sometimes employed.

ROOF TRUSSES; ECONOMICAL SHED DESIGNS

Roof trusses should be spaced from 2 ft. to 2 ft. 6 ins. apart. Where rough timbers are elsewhere employed, it is advisable to have the tie-beam of sawn timber, because it is impossible to get a round pole which, at the same time, is strong and light enough. Do not use too thick timbers, on account of the

weight ; 4-in. diameter at the butt end is enough. For a rough timber roof, the external walls of the building should be at least 14 inches thick. For connecting the timbers, use preferably $\frac{3}{8}$ in. bolts, one at each joint. The timber must be well seasoned ; if not, it will split and shrink and the bolts will become loose. In any case, the bolts should be examined some time after the completion

FIG. 230.

FIG. 231.

of the roof, and all loose nuts tightened. In roofs of rough sheds, if the thatching laths are thicker than $1\frac{1}{2}$ in. diameter, say $1\frac{3}{4}$ in. to 2 in., the roof trusses may be placed 3 ft. apart.

Figs. 230 and 231 show roof trusses for thatched roofs of 16-ft. and 25-ft. span respectively, the timbers being all rough natural poles, except the tie-beams.

Fig. 232 illustrates a roof truss of sawn timbers for a span of 20 ft.

FIG. 232.

The type of open ridge in Fig. 233 is used in Rhodesia for cow-byres, etc.

FIG. 233.

Sheds.—Fig. 234 is a cross section of a forage shed of two spans or bays, while Fig. 235 gives details of the guttering between the two adjacent roof-slopes.

Figs. 236, 237, and 238 give details of a shed erected at the Experiment Farm, Potchefstroom. This shed has its sides thatched in, and is used as a tobacco drying shed. The thatching of the sides consists of reeds, stood up between double wires stretched from post to post.

Figs. 239 and 240 give particulars of the type of lucerne shed in use along the Mooi River, Potchefstroom, with nave and two side aisles. These drawings

Fig. 234.—Forage Shed.

were made from an existing shed, in a fairly well sheltered position. Where such a shed is exposed to wind, the rafters should be closer together.

FIG. 235.

LOWER 3 FT. OF POSTS TYPED
AND BEDDED IN CONCRETE

ENDS OF SHED

FIG. 236.

PRINCIPALS (EXCEPT AT ENDS)

FIG. 237.

COMMON RAFTERS

FIG. 238.

PRINCIPALS.

FIG. 239.

PRINCIPALS AND COMMON
RAFTERS ALTERNATE AT
8' INTERVALS, THUS AD-
JACENT RAFTERS ARE 4'
APART.

COMMON RAFTERS

FIG. 240.—Forage Sheds in Rough Timber.

Protection from Lightning.—The protection from lightning of a building with a thatched roof is made clear by Fig. 241. The object in view is the enclosure of the building in a kind of metal “cage,” and for this purpose stout barbed wire may be used, connected to the galvanised iron roof-capping and carried down into the ground, where each wire is joined to a paraffin tin

FIG. 241.

buried in the earth. This provides the lightning with a path to earth. The paraffin tins are set open end up, and, by retaining water, form an excellent “earth.” Another form of simple “earth” consists of a tangle of wire buried a few feet in the ground; dampness of the latter improves the “earth.”

All projections above the roof should be protected. Note the barbed wire

carried across the chimney and joined at each end to the metal flashing; also the wire on each gable, connected to the roof-capping. All joints and places where wires cross each other should be good metal-to-metal joints, well soldered. Bends in the wire should be gradual, not sharp. The arrangement of wires and paraffin tins at the back of the building is similar to that shown for the front. The barbed wire is simply laid on top of the thatch. While the protection afforded by the above system is fairly complete, there is still a risk of the thatch being ignited by a flash of lightning which has not been preceded by rain. Insulating the barbed wire from the thatch, *i.e.* by supporting it on the necks of glass bottles, is of questionable efficiency, because sparking (on the lightning striking) is so extensive that the danger of ignition is almost as great as before.

If a building is near to tall trees, without being so near as to suffer damage in the event of one of the trees being struck by lightning, the danger to the building is much lessened.

PLAN OF A SMALL FARM DAIRY

THE accompanying plan (Fig. 242) is of a small farm dairy, suitable for the farmer who sells milk or cream or makes butter. Such a dairy should be situated conveniently near to the cow-byre; indeed, it is often built against the byre as a lean-to or otherwise. In the drawings, a separate building has been shown.

If more room is desired than shown in the drawings, the milkroom and the washroom might each be made 10 feet wide, in place of 8 feet.

The building should preferably be placed so that the milkroom is at the cool side with regard to the sun, existing shade, etc., the position of the cow-byre also being taken into consideration. A suitable position for this dairy is shown in Fig. 245.

Whenever possible the building should be on high ground with good natural drainage. In accordance with the Dairy Industry Act, 1918, the dairy should not be less than 150 feet from any piggery, manure heap, or offensive stagnant water.

The walls of the building are of stone, 18 inches thick, and the eaves overhang 2 feet (horizontally) beyond the walls, for the sake of coolness. Immediately under the eaves an air-brick ventilator is built into the outer wall of each apartment, *i.e.* eight ventilators in all. The rooms are ceiled, and louvered openings are provided at each end of the corrugated iron roof. As an alternative to stone, brick walls might be adopted, hollow or cavity walls being erected in order to make the building as cool as possible. The following methods of heat insulation, mentioned on page 301, may also be employed:

- (1) If the building is near the coast a thick layer of dry seaweed should be laid on sheets of paper on the top of the ceiling, *i.e.* between ceiling and roof.
- (2) If the building is distant from the coast the place of the seaweed may be taken by a layer of wood charcoal 6 inches thick.

FIG. 212.

the granolithic, consisting of (1) a layer about $\frac{3}{4}$ -inch thick, of one part cement to one part clean sand to three parts granite chips capable of passing a $\frac{3}{4}$ -inch square mesh. (2) An upper layer $\frac{1}{4}$ -inch thick, consisting of one part cement to two parts granite chips capable of passing a $\frac{1}{4}$ -inch mesh.

If it is desired to finish the granolithic "red," the requisite quantity of red oxide of iron should be added to the materials for the finishing layer [(2) above]. The granolithic is turned 4 inches up the walls to form a skirting, with the corners rounded.

A sliding door is installed between washroom and milkroom, and also between washroom and boiler-room. The outer doors are hung in two heights, so that the upper half can be left open while the lower is closed.

CROSS SECTION ON "AB"

FIG. 242B.

The walls are finished inside by rendering or plastering the lower 4 feet with 1 : 3 cement mortar, and the remainder with lime mortar of the same proportions. For the lower portion, however, if expense is no object, white glazed bricks probably form the best finish.

In the washroom a sink is provided, preferably of white glazed stoneware, carried on a brickwork pier. The latter should be plastered with cement mortar smoothly finished. The waste-pipe from the sink may discharge through the party wall into the gutter in the boiler-room. In connection with the sink is a drain-board (grooved and sloping towards the sink) on which cans, etc., may be

placed to drip after having been washed. In addition, a shelf of open spar-work is provided above the drain-board, while in the milkroom are two solid shelves for the reception of dry milk cans. An open spar-work platform is placed in front of the sink for standing on.

The hot-water system consists of a vertical boiler and hot-water cylinder connected by piping, as shown; the water circulation is indicated by arrows (see elevation). The system is supplied from a supply tank on the roof, from the bottom of which tank a pipe leads to the bottom of the hot-water cylinder. The supply tank is replenished from the main, through a ball-cock. From the top of the hot-water cylinder an expansion pipe, for the escape of steam, takes off, and may be either bent over the supply tank so as to discharge into it or carried through the roof. As an additional precaution, in case of the expansion pipe becoming choked through deposit from highly mineralized water or otherwise, a small safety valve, set to open at a comparatively low pressure, should be attached to the boiler. The service pipe to the hot-water tap or taps branches off from the lower end of the expansion pipe.

A list of some of the quantities of materials more difficult to estimate is appended. It is only approximate, however, because the quantities used depend greatly on the particular workman, and on other circumstances, such as the size of stones used in building, etc. :—

Bricks for party walls, 3000 bricks. Mortar for walls, 42 bags blue lime ; 1 5 cubic yards sand. Materials for floor, $15\frac{1}{4}$ bags Portland cement ; $1\frac{3}{4}$ cubic yards sand ; $2\frac{3}{4}$ cubic yards broken stone to pass a $2\frac{1}{2}$ -inch ring ; $\frac{3}{4}$ cubic yard broken granite to pass a $\frac{3}{4}$ -inch ring ; $\frac{1}{4}$ cubic yard granite chips to pass a $\frac{1}{4}$ -inch ring. Materials for lintels and sills (of 1 : 2 : 3 concrete), $7\frac{3}{4}$ bags Portland cement ; 1·1 cubic yards sand ; 1·6 cubic yards broken stone, to pass a 1-inch ring. Cement plaster for lower 4 feet of walls, $5\frac{1}{2}$ bags Portland cement ; $1\frac{1}{4}$ cubic yards sand. Lime plaster for upper 6 feet of walls, $6\frac{1}{2}$ bags blue lime ; $2\frac{1}{2}$ cubic yards sand.

The quantities of timber, corrugated galvanised iron, piping, etc., can readily be measured from the drawing, which is sufficiently detailed for the purpose. It is better for the person who is responsible for the work to do so than to rely on a list of materials, because in the former case he gets a better understanding of what each piece of material is for.

FURTHER LAY-OUT PLANS OF STEADINGS

FIGS. 243 and 244 give the arrangement of a steading for 32 cows, and also with the other accommodation shown. The buildings are arranged in two contiguous rows for the sake of cheapness. This arrangement is also very compact, but presents the difficulty that cross-ventilation and lighting are difficult to arrange

for. In the present case these have been allowed for by the insertion of skylights, as shown both in the plan and cross section. The large, undivided calf-pen is for the collection of the calves previous to milking time, calves not being hand-fed in this instance.

Fig. 245 is the arrangement-drawings for a large steading with accommodation for 60 cows, and also with bull-boxes, calf-pens, loose-boxes, feed-rooms, silos, piggery and small dairy. Buildings on this plan have been erected by Mr. T. Louw, at Holmdene, near Standerton, but corrugated, galvanised roofing was adopted in place of tiles. In the cow-byre, divisions of reinforced concrete are installed. The calf-pens are formed of $1\frac{1}{4}$ -in. galvanised iron piping and Pittsburgh "Perfect" electrically-welded "Lawn" fencing. The floor and mangers are of concrete. The piggery is of the large-house type, and adjoins the pig-grazing camps. The partitions between the exercise yards are of old boiler tubes with pig netting stretched between them. This type of construction, like that used for the calf-pens, allows of free air circulation throughout the whole row of yards or pens and helps towards coolness. The drainage system is clearly indicated in the drawings.

Fig. 243.—Farm Buildings compactly arranged : Elevation.

Fig. 243A.—Buildings compactly arranged : Plan.

CROSS SECTION OF COW-BYRE AND HORSE STABLE
FIG. 214.

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