

BRICKEARTHS, POTTERY & BRICKMAKING IN GLOUCESTERSHIRE

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INTRODUCTION.

The subject of this paper may not appear, on first consideration, either very interesting or very important, but most people should have some idea of how a brick is made and pottery is produced; and it is hoped that in addition to supplying this information, this paper will not prove unacceptable to those to whom the selection of brickearths and brickmaking are matters of more immediate concern.

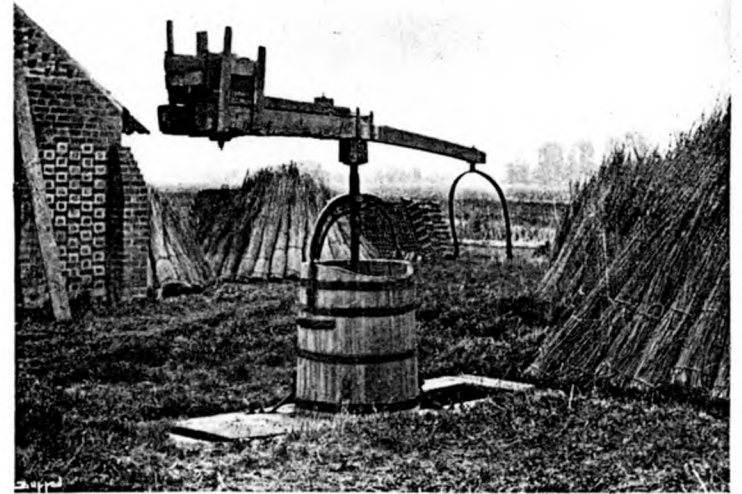
As regards land-relief, Gloucestershire may be divided into three parts—an upland, vale-land, and hill-valley district. The first bears the name of Cotteswold Hills, and is mainly capped with limestone; the second comprises the Vales of Bourton, Moreton, Evesham, Gloucester, and Berkeley, which are mainly floored with Lias clay; while the third embraces the northern part of the Bristol Coalfield and the Forest of Dean, wherein both limestone and clay prevail. Hence, as might be expected, stone is the chief building-material in the first, brick in the second, and stone *and* brick in the third.

PART I.

In order that the reader may have a correct idea of where the deposits that have been utilised for brickmaking in Gloucestershire occur in the earth's crust, the following table is presented (Table I.). The Systems and Series in *italic* are those represented in part or whole in Gloucestershire.

In addition to this table, however, it is necessary to give a second (Table II.), to show the yet further sub-divisions of certain Series, and of these, those in *italic* have been tried for brickmaking, but have failed to withstand the test; while those in *italic*, and with an asterisk as well, are being worked at the present time. In brief, the geological names of the deposits that are at the present time being worked in Gloucestershire for brickmaking are:

- (1) The Alluvium of the Severn-side,
- (2) The basal Upper-Lias deposits,
- (3) The basal Middle and topmost Lower Lias,
- (4) The red Upper-Keuper Marls, and
- (5) Certain of the clay-scams of the Coal-
Measures.



G. S. Railton, Photo.

**PUG MILL AT LOWER LODE BRICKWORKS,
near Tewkesbury.**



CRANHAM POTTERY

TABLE I.—GENERAL CLASSIFICATION OF THE ROCKS TAKING PART IN THE FORMATION OF THE EARTH'S CRUST.

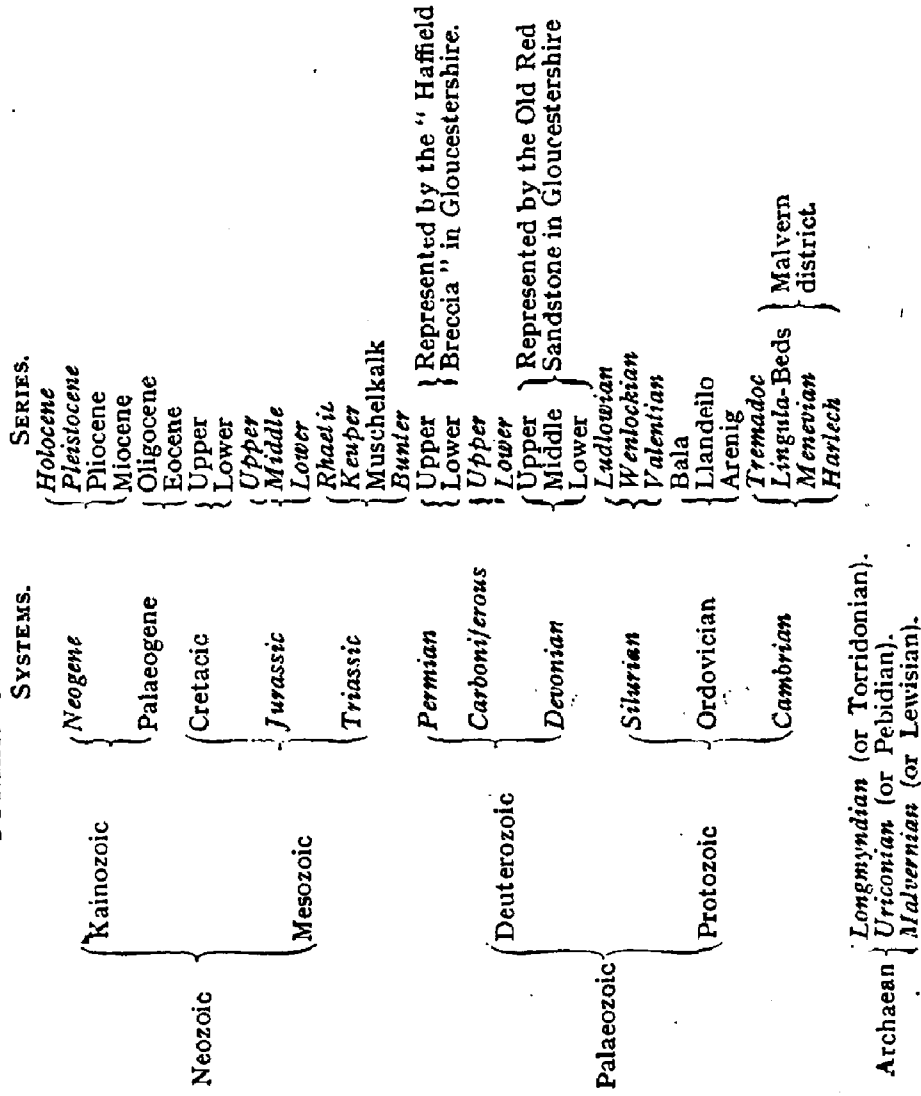


TABLE II.

ROCK GROUPS PRESENT IN GLOUCESTERSHIRE.

	Neogene { Holocene Pleistocene }	Alluvium.* Certain sand and gravel deposits. Absent from Gloucestershire.]
	[Palaeogene and Cretacic	
	Upper	{ Purbeckian Portlandian Kimmeridgian Corallian Oxfordian Cornbrash Forest Marble Great Oolite Fullers' Earth. Inferior Oolite Upper* Middle* and Lower Lias* }
Jurassic	Middle	
	Lower	
Triassic	{ Rhaetic Keuper [Muschelkalk. Bunter }	Upper Keuper Marls* Absent from Gloucestershire]
Permian		
Carboniferous	Upper	{ Coal-Measures* Millstone-Grit Upper Limestone Shales Mountain Limestone Lower Limestone Shales }
	Lower	{ Upper* Pennant-Grit Lower* }
Devonian	Old Red Sandstone and Marls*	
	Ludlowian	{ Downton-Castle Sandstone Shales Aymestry Limestone Shales }
Silurian	Wenlockian	{ Wenlock Limestone Wenlock Shales Woolhope Limestone }
Ordovician	Valentian (May Hill Sandstone) [Absent from Gloucestershire.]	
Cambrian	{ Tremadoc Lingula-Beds Menevian Harlech }	{ Malvern Shales and Hollybush Sandstone Malvern Quartzite }

HISTORICAL RETROSPECT.

Brickmaking has been engaged in from very early times, and it is not surprising to find that in the opinion of early man the practice had its origin with the gods. The early Egyptian, meditating upon the origin of man, concluded that his figure was moulded by the god Num out of the black mud of the Nile, and that into the nostrils of this image was breathed the breath of life.

Many early peoples, desirous of accounting for their origin, eventually evolved and developed this view; and early writers have it that the descendants of the sons of Noah essayed, on the plains of Shinar, the prodigious task of reaching heaven by means of a tower constructed of burnt bricks.

Burnt bricks were made out of the clay that was excavated from the trench which surrounded ancient Babylon, and were used in the construction of the city walls.

In Nebuchadnezzar's reign it was his custom to have his name stamped on every brick, and Sir Henry Rawlinson, the Oriental scholar, in examining the bricks in the walls of the modern city of Bagdad, discovered on each brick clear traces of the *fac-simile* of the Royal signature.

Sun-dried bricks were extensively used in ancient times, especially in Egypt, where, under Rameses II. (or "Pharaoh," as he is perhaps more commonly called), the Israelites laboured in their manufacture. One can still see on the tombs of Thebes pictures showing the process of the brick-making: some labourers carrying the water wherewith to temper the clay, others carrying clay to the moulders, others, again, bearing off bricks and laying them on the ground to dry; and yet others carrying off the sun-dried bricks on shoulder-yokes to the builders. The full significance of the Biblical statement that "Ye shall no more give the people straw to make bricks, as heretofore: let them go and gather straw for themselves; and the tale of the brick which they did make heretofore ye shall lay before them," becomes more evident when it is remembered that the mud of the Nile then, as now, was the only material in Egypt suitable for brick-making,

and required then, as it does to-day, chopped straw to make it at all adherent. In those early days, as is still the case, most of the bricks were sun-dried, and the few burnt ones that were made were employed in the river-walls and hydraulic works.

It is thought that brickmaking was a Royal monopoly in Egypt.* Thothmes III. is believed to have been on the Throne at the time of the exodus of the Hebrews. A sun-dried brick of his reign, measuring 12" by 9" by 6 $\frac{3}{4}$ ", is preserved in the British Museum, and has impressed upon it his cartouche—an oval with the hieroglyph signifying his name stamped on it.

Sun-dried bricks never became hard enough to withstand the action of water. This fact was made use of by Agesipolis, King of Sparta, who conducted the water of the Ophis along the base of the walls of Mantinea, and effected their collapse; but for ordinary outside ware, a stucco, believed to have been composed of burnt chalk and plaster, was used to form a protective coating.

Bricks, burnt and unburnt, were employed in the construction of the great wall of China, which was completed in 211 B.C. This wall totalled about 1,250 miles in length, and averaged 22 feet in height, and was wide enough at the top for six horsemen to ride abreast.

The earliest method of constructing shelters with the aid of mud or clay was that known as "wattle and daub." This, probably, is the reason why so few remains of pre-Roman habitations are now to be found. The Romans, who made both burnt and unburnt bricks in profusion, introduced brickmaking into this country, employing large flat bricks or wall-tiles to bond their rubble constructions. Such wall-tiles continued to be used in England until the rubble work was succeeded by regular masonry in Norman times. Even then the use of tiles did not go altogether out, for Canon

*It may be of interest to add that Kaiser Wilhelm II. has a pottery and majolica-ware factory of his own in Kadinen. In order that the products of this factory may become more known the Kaiser has opened a shop in the Leipsigerstrasse in Berlin to exhibit his Kadinen ware.

Bazeley informs us (*in litt.*) that "The Normans certainly used tiles made of brick-earth. You may see them in the joints of the pillars of the Nave of Gloucester Cathedral, and, if I remember rightly, there is a good deal of Norman brick or tile-work at St. Albans. It has been thought that the tiles at Gloucester were Roman, but it is more likely that they were of Norman make." For the less pretentious erections it is probable that old methods were continued even longer; but by degrees the practice was developed of having low stone walls, with lath and plaster work above. For general purposes the black-and-white or lath and plaster work prevailed until Tudor times, but in Henry VIII.'s reign the art of brickmaking attained to a very high degree of perfection, as the numerous pieces of fine work that were accomplished about that time, and still extant, bear witness.

But, although bricks had come into common use in Henry VIII.'s time, in Elizabeth's, it is stated by Mr. E. Dobson in his excellent work on "Brick and Tile-Making" (1899), page 5, that they were only employed for the large mansions, timber frame-work, with the intervals filled in with plaster, being still in use, and only a later practice was that of "brick-nogging," or the filling up of the intervals between the timbers with bricks.

It is interesting to notice that the general use of timber* preceded that of brick, and that the use of brick was partly necessitous, for the virgin forests that could be formerly drawn upon were fast going, and were being replaced by a younger growth.

"On the rebuilding of London after the great fire of 1666, brick was the material universally adopted for the new erections, and the 19 Car. II., c. 11, regulated the number of bricks in the thickness of the walls of the several rates of dwelling-houses. Much of the brickwork still remaining in London, in buildings erected at the end of the 17th century, is very admirably executed. The most remarkable feature of the brickwork of this period is the

*In mediæval times chestnut was largely used for constructional purposes in Gloucester.

introduction of ornaments carved with the chisel."

At the close of the 18th century bricks were taxed, the 24 George III., c. 24, imposing a duty of 2s. 6d. per thousand on bricks of all kinds. Duties of various amounts, sometimes as much as 5s. 10d. per thousand, were levied between this time and 1850, in which year, however, they were entirely repealed.

In 1854 the number of bricks manufactured in this country was estimated at over 2,000 millions. This is not surprising when it is remembered that the lining of an ordinary tunnel consumes about 8,000 bricks for every yard of length.

Before finishing this historical retrospect, it may be of interest to add that brickmaking has been practised in Cheltenham since Alfred the Great's time. In the Public Library there is a copy of an interesting legal booklet (1863), in which (on page 93), in the case of William Gyde *versus* the Lord of the Manor of Cheltenham, there is this statement: "Brick-making has gone on here for the last five or six hundred years—nay, even from the time of King Alfred the Great, now some nine or ten hundred years ago: for I find in the history of the town by Rudder that Cheltenham derives its name from being a town of clay. The general opinion is that the name is derived from the river Chelt, but Rudder says it is derived from the Saxon word 'cyle,' from the great amount of clay which is found here in ancient times; and, strange to say, King Alfred (so Rudder tells us) introduced artisans from foreign countries, and thus, curiously enough, he was the first brickmaker in Cheltenham, and, in fact, started the trade."

Qualities to be considered in selecting brick-earths.—In this paper the term "brickearth" is not used in its strict geologic sense, but to denote any deposit that is suitable for making into bricks. Geologically speaking, a brickearth is a loamy, superficial deposit, sometimes simply old alluvium, at others a loess, or may be a rain-wash accumulation not far removed from its source of derivation.

A good brick can always be detected by its uniformity of texture and metallic ring when struck. It will be free from cracks and flaws, hard, regular in shape, uniform in size, and—if for ornamental purposes—in colour as well, easily cut, and—if required for situations exposed to intense heat—infusible. Now these qualities in the final product all depend on the selection of the brickearth, its preparation, and the careful drying and burning of the "green" brick.

The materials available for brickmaking are :

- (1) *Pure, strong, or fat clays*, which are mainly composed of silicate of alumina, with a small proportion of such substances as lime, etc. ;
- (2) *Marls*, which are calcareous clays ;
- (3) *Loams, or lean clays*, which, roughly-speaking, are half clay and half sand ;
- (4) *Fire-clays*, which are hydrated silicates of alumina, practically without any such substances as lime, magnesia, etc., that act as fluxes ; and
- (5) Sand and limestone (*see below*).

It very rarely happens that an earth is found which is suitable for making into bricks without some admixture. Thus, a strong clay requires the addition of a "milder" earth, such as loam or sand, or of "grog," such as burned clay (ballast) or broken brick ; while a lean clay is often so incoherent that it requires the addition of some flux, such as lime, to bind it. But, even when an earth requires no admixture, such as that used so extensively in Gloucestershire, and derived from the *Capricornus-Zone* of the Lias, which is a loam to start with, grinding is advisable, for deposits vary considerably in constitution in a very short distance, and so any approach to uniformity in product can only be assured in this way.

A "strong" clay, which, when properly mixed with water into a plastic condition, can be readily moulded, will make a good, strong brick with heavy machinery and proper drying. But the drying of a "strong clay" brick is a very delicate operation, for the brick is very sensitive to draughts or hot sun, cracking in all directions if any but a slow speed of drying is

exceeded. It costs more in fuel to dry a green, strong clay brick than to burn it, and the burnt product is hard, tough, and will not "cut" or "rub" so readily as bricks from leaner or weaker clays.

On the other hand, a lean clay or loam is more readily and inexpensively made into a strong brick, and dries in one-fifth, or less, of the time. This is due to the presence of sand. Sand does not destroy the plasticity, but lessens the amount of sprinkage and possibility of cracking in drying, and rending and warping when the brick is subjected to a red heat. Also it makes the bricks capable of being cut or rubbed down for gauged work.

Marls are calcareous clays—that is, lime and finely-divided silica, with certain impurities. They have to be ground before they become sufficiently plastic, but make an excellent brick.

Fire-clays owe their property of great resistance to becoming fused ("or refractory property") to their lack of any appreciable amount of substances that act as fluxes, such as lime, magnesia, or metallic oxides, and, when subjected to the heat of the kiln, *bake* rather than *burn* (or vitrify).

Of the making of bricks from sand and lime details will be given later.

Thus, in selecting a brickearth for the manufacture of building bricks, a clayey-loam appears best. Such a deposit the *Capricornus-Beds* furnish, and they are worked more than any other deposit in Gloucestershire for ordinary brickmaking. The loam or alluvium of the Severn-side is a little too loose and wet. The blue (and the yellow at the top is only hydrated blue) Lias clay is generally too strong, and usually has to have a milder earth mixed with it. At the Battledown Brickworks there is sand from the superficial deposit available. If it were thought of opening a brickyard in the Lias anywhere out in the vale-land in the Cheltenham and Gloucester areas this side of the Severn, care should be taken to see that there is sand from this source available close at hand. At Brockworth such sand is mixed with powdered limestone from the hills: the two are ground together, and put through a process which ends

in the production of a strong lime-silica brick. This suggests that in districts where the Millstone-Grit and Carboniferous Limestone occur, silica-bricks might be made from the weathered grit and crushed limestone.

UNSOILING.—When, with or without expert assistance, brickearth likely to be suitable has been discovered, the first step towards opening a pit is to remove the turf, etc. Then, having dug the brickearth, of whatever nature it may be, the next step is to render it suitable for shaping into bricks.

TEMPERING AND MOULDING.—Several processes are at the disposal of the brickmaker:

1.—The brickearth, commonly called *clay*, can be dug, heaped up, and watered, and exposed to the weather—frost, rain, and sun. When it is sufficiently *weathered*, it can be made into bricks, either

- (a) By the hand-made or *slop* process;
- (b) By machinery, including *pug-mill* and *cutting-table*; or
- (c) By a combination of machine and hand-work.

2.—The clay can be *got* either by the human or steam navvy (the latter being able to do the work of one hundred men), and made directly into bricks, without previous weathering, either by

- (d) the *semi-dry* process;
- (e) the *semi-plastic* process;
- (f) the *plastic* process.

So far as Gloucestershire is concerned, the steam-navvy has yet to make its appearance, although it is not unknown in the history of brickmaking in the county, as it has been employed in temporary yards worked by railway-contractors in railway-construction work.

The primitive SLOP process (1 a) is still observed in the hand-made brickyards, such as those on the Severn-side, where the alluvium, or "surface clay" is dug and weathered during the Autumn and Winter, and made into bricks by the slop-brickmaker in the Spring and Summer.

After moulding each brick singly in the mould on his bench, the *green* brick is carried off to the drying-ground or *hack*, and when a sufficient

number are dry, they are wheeled away, and set in either *clamps* or *permanent kilns*, and burnt.

Limestone-nodules should, of course, be carefully picked out before the moulding is done; and if they are too numerous or too small to permit of this being done by hand, the clay will have to be washed—an expensive and tedious affair. Washing is effected by mixing water with the clay in a *wash-mill* or trough, and running off the liquid pulp through a grating, to prevent any small stones from getting through. The liquid pulp is then left in a prepared pit until the clay has settled and the water has been drained off or evaporated.

In most Gloucestershire yards machinery is now largely employed to take the place of weathering and to do the tempering, and in the largest brickyards the clay is taken direct from the pit to the machine.

In the SEMI-DRY PROCESS (2 d above) the clay is taken to a dry revolving pan on the ground-floor level of the brickyard. This pan has a perforated bottom, through which the ground dry clay passes, and from thence it is lifted by an elevator to the topmost tier of the mill-building, where it is emptied on to a screen, made of piano-wire. The portion that does not pass through the screen is returned, automatically, to the revolving pan, there to be re-ground. The fine dust clay which has passed through the piano-wire screen is then carried by a machine-conveyor to the power-driven brick-press, and after being moulded, under considerable pressure, the brick is taken out in its semi-dry condition, and can be carried either direct to the kiln, to be burnt, or be put on a drying-floor, preparatory to going to the kiln.

The SEMI-PLASTIC PROCESS (2 e above) is practised at the Robins' Wood Hill Brick and Tile Works. There the ordinary bricks are made in a Bradley and Craven semi-plastic machine, the clay being ground in a perforated pan, then conveyed by means of elevators to a room above, thence to a mixer, in which water is added, and the clay is made plastic. It is then conveyed to an upright pug-mill, through

which it passes, and is forced into the several boxes fixed round a rotary table. This, in turning, brings each box opposite the die-box, into which the clay is pressed, under great pressure. The brick is then either stacked in drying sheds or taken direct to the Hofmann Kiln.

In the ORDINARY PLASTIC PROCESS, which is probably the most generally used of them all, the clay is hauled up an incline from the pit to the top of the machine-house. There it is tipped into a hopper, and descends by ordinary gravitation—aided by the grabbing power of different rollers—through various sets of rollers (which vary considerably in size and number, according to the nature of the clay) to a *mixer*, and then to the *pug-mill*. This is usually a horizontal machine, with a long internal shaft, with very heavy iron knives, forming a rough kind of screw or propeller. This forces the clay forward, and, with the aid of a *worm*, or heavy iron screw, on the forward end of the shaft, the clay is forced through a *die*, about ten inches wide by five in depth, and issues as a column of plastic clay, ready for being cut on a wire-cutting table into any number of bricks up to twelve at a time.

The reader will have noticed that there are two methods of preparing the clay. The one is by digging, and weathering simply by the aid of Nature, and the other is by passing the clay through machinery. Where any large number of bricks is required, the former process occupies too much space and restricts the output too much. Consequently, the machinery process is more largely employed, and not only does it considerably increase the output, but it allows the work to be done in a much more compact area.

As to what machinery is required for the tempering process, no fixed rule can be laid down. Almost every yard varies in its requirements. So great is the variation of the clay, from a brickmaker's standpoint, that two brick-yards within a mile of each other may require quite different machinery, or machinery on a different principle, to get the best results.

We have stated that the bricks made by the

Semi-Dry Process can be taken direct to the kilns and burnt, without intermediate drying. It is, however, often found advisable to put them through some process of drying before going to the kiln, and in any case, with bricks made by the Semi-Plastic, Plastic, and Ordinary Hand-Made processes, this is absolutely necessary.

DRYING.—Several processes of drying are in vogue amongst brickmakers. There is (1) the ordinary *hack-drying*, which is done by placing the green bricks, one by one, on a prepared piece of ground, covered either with some more or less permanent wooden covering, or (2) after the bricks are *hacked* up three, four, or more high, they can be covered by hand with some temporary straw or other covering. When they are first set down to dry, they are placed one upon the other, as close as the bricks in any wall or building, as they are too limp to be placed any other way; but, after they have stiffened sufficiently they are *skintled*—that is, placed in such a relative position to each other that a current of air can pass freely around the bricks, thus accelerating the drying. This is the process usually employed in the hand-made yards. Or (3) the bricks may be taken to a heated shed floor, composed either of concrete or iron-plating, under which run flues that are heated either by fire-holes at one end of the building, or by live or exhaust steam. Then there is a fourth, (4) and still more modern, and, incidentally, more expensive, arrangement, which is to put the bricks on double-deck dryer cars, some 600 to a car, and run the cars into a so-called *tunnel-dryer*—a room kept at a Turkish-bath degree of heat, and from which the bricks are brought out at the other end properly dried.

The processes enumerated above take, say, some three weeks to a month to dry in the open-air, and from two to six days if artificially dried.

Considerable care is required in drying green bricks, and it is probable that far more waste occurs in the drying process than in the burning. In many brickyards, especially in those that have to deal with strong clays, the drying part of the operation costs more in fuel than the actual burning.

POWER.—The brickmaker who decides to make his bricks with the aid of machinery will have to choose the form of power to employ to drive his machinery. The choice must be made from :

- (1) Steam-boiler and engine.
- (2) Gas-engine driven by (a) town gas or (b) producer gas.
- (3) Electric motor (a) from town mains, or (b) steam-engine or gas-engine and dynamo in his own yard.

Various considerations must guide him. If water be plentiful and cheap, then the modern steam-engine is difficult to surpass, and the exhaust steam can be usefully employed for drying-purposes. Many brickyards now have gas-engines installed,* and a gas-producer plant for making the gas on the spot. The gas is either *pressure* or *suction* gas, both being made by passing dry steam and air over incandescent anthracite-coal.

Perhaps the chief disadvantages of the gas-engine are :—(1) the large oil bill, and (2) inutility of the exhaust for heating purposes.

Power is a very important item for the would-be brickmaker to study. Usually he finds he has too little, as brickmaking machinery has a knack of going very hard, and requiring a considerable amount of power.

Machinery is, of course, equally important, and having chosen the right kind of substantial build for the clay, it requires to be well-erected and well-maintained.

BURNING.—Having now made the brick, and dried it, the next process is to burn it in kilns, which may be either temporary, such as *clamps*, semi-permanent, or permanent. The clamp is but a primitive way of burning, and is not much used in Gloucestershire. Kilns may be either *up-* or *down-draught*, or a combination of the two.

There are many ways of constructing kilns, and scarcely any two are exactly alike ; but they are generally modifications of four main types. These are :

*We believe that the first gas engine used for brick-making in the United Kingdom was a Crossley 49½ I.H.P. engine erected at Messrs. Webb Bros. Ltd., Battledown Brickworks, Cheltenham, in 1893.

(1) The *Scotch* or *common rectangular kiln*, with fire-holes in the side-walls exactly opposite each other, with narrow doorways at the ends for setting and drawing, and with or without a permanent roof.

(2) The *rectangular kiln*, similar to the above, but with two arched flues running under the floor the whole length of the kiln—the furnace doors being at the end. The floor of the kiln is generally formed like lattice-work.

In both these types, if the roof is not a permanent one, either old bricks, earth, boards, or a moveable wooden roof is put on the top, to protect the burning bricks.

(3) The *Cupola*, or *circular kiln*. This, as the name implies, is circular, has a domed roof, with openings in the walls for fire-holes.

(4) The *Hoffman* regenerative or continuous type of kiln.

It is unnecessary to detail how the bricks are set in the kiln, but it may be mentioned that the heat should be got up gently, and only increased to the full when the steam ceases to rise, for, when this ceases, it will be obvious that the green bricks are quite dry. The kiln should be allowed to cool very slowly, as the soundness of the bricks is much impaired by opening the kiln too soon.

TILES.—It may be advisable to state here that tiles are manufactured by much the same process as bricks : the only essential difference is that they are thinner, and therefore require a well-prepared clay. Tiles may be thus classified :—

- (1) *Paving-tiles*, which are simply thin bricks.
- (2) *Roofing-tiles*—(a) Pantiles, (b) Plain tiles.

A *pantile* is moulded flat, and afterwards bent into the required form on a mould ; while a *plain tile* is moulded flat and has a hole for the reception of the tile-pins, or may be instead, or in addition, a *nib* at the head. Plain tiles are bent to form *hip*, *ridge*, or *valley-tiles*.

Draining-tiles are either made flat and then bent round a cylinder and joined, or—as is generally the case now—are made by mechanical means : the clay is forced through a die, and the length of pipe is cut off as the shaped pipe is expressed.

PART II.

DESCRIPTION OF GLOUCESTERSHIRE
BRICKWORKS.

GENERAL.—As mentioned in the Introduction to Part I., the deposits which are worked in this county at the present time for the purpose of making bricks are: the Alluvium (Holocene); certain portions of the Upper, Middle and Lower Lias; the Upper Keuper Marls; and certain of the Coal-Measure clays. But other deposits in addition to these have been tried in times past, such as the Oxford Clay, Fullers' Earth, and Old Red-Sandstone Marls; but they have not proved very satisfactory. Nevertheless, it has been thought fit to record where such unsuccessful attempts to produce bricks have been made, and, as far as possible, what were the most likely causes preventing the enterprises being carried on successfully.

The several deposits may be discussed in their order of geologic age—the youngest first; the oldest last. The youngest or newest deposit used in Gloucestershire for brickmaking is the Alluvium.

I.—ALLUVIUM.

GENERAL.—Alongside the River Severn there are rich, flat pasture-lands, of various breadths, which owe their wealth of grass and its rich green hue to the nature of the underlying soft deposit and periodic inundations by the river. When the floods have retreated they are found to have left behind them, over the surface of the fields, a thin coating of fine mud (or silt). This periodic deposition of sediment has been going on year after year, and by degrees the river has built up its bed, and has margined itself with thick deposits of this fine material or *alluvium*, as it is called by geologists. Alluvium, then, is the detritus that has been worn off from the rocks higher up stream, and brought down by the waters to be deposited when suitable conditions obtained.

Between Tewkesbury and Purton Passage the alluvium varies considerably in breadth; but between Berkeley and Oldbury-on-Severn

it spreads out, and forms a very considerable expanse between Aust and Avonmouth.

It is not hard to detect ground formed of alluvium. It is generally beautifully level; a rise of greater or less prominence marks the transition from it to the older rocks, and the streams find their way across it very sluggishly. When dug into, it is generally found to be easy to shift, being loamy, or mild, as the brick-makers would say. It is of considerable thickness in places, and locally has interpolated in it beds of peat. To the geologist the ordinary top-alluvium of the Severn-side would appear to vary but little in consistency; but brick-makers can detect numerous differences, often of no small importance to them. No grinding is essential to render it fit for the moulders to shape into bricks. Ordinarily, it is dug in the winter months, and wheeled out to be weathered and tempered by spade-work. Then, in the summer months the green bricks are moulded by the primitive hand process, already referred to, which is called the *slop-process*.

In times past there were many brickyards by the Severn-side, but now the only ones in work are those at the Lower Lode, Walham, and Llanthony. Bricks, known in building-circles as "Severn-side Bricks," are the main article manufactured. They burn to a nice, uniform red colour, but would appear to be somewhat porous or absorbent, and scarcely capable of standing the crushing-strain required for heavy engineering work. Practical builders, however, tell us that they are better than they look, and bricks from Walham and Llanthony have been largely used in Gloucester city in the past. Pressed bricks (pressed by hand) are also made at these Severn-side works; but not in any quantity. Some fifty years ago large numbers of agricultural drain-pipes were turned out (principally of two sizes: two inches and four inches in internal diameter); but now there is little demand for them, as most of the draining is said to be finished. For drain-pipe making it is necessary to grind the alluvium.

Pantiles were also produced, but were not very satisfactory, being too soft, porous, and thick. All tiles made of Severn-side alluvium

are somewhat porous, and, while very excellent for out-houses and shed-roofing, are scarcely the ideal for dwelling-house roofs. Some of the old houses in Apperley, near Deerhurst, are roofed with local tiles, and Severn-side bricks have been extensively used. The combination of red-brick walls and straw-coloured thatch is decidedly pleasing, and it is interesting to find so many cottages in this district newly-thatched, for in many country-parts the knowledge of how to thatch has almost, if not entirely, died out.

Lower Lode, Tewkesbury.—It is easy to see where the alluvium occurs in this neighbourhood. The flat expanse of the Severn Ham and the level fields by Deerhurst are formed of it. In the past it has been extensively worked for brick-making, pits being situated by the river-side just above the Mythe Tute and at the Upper Lode. Now these are abandoned, and the only pit open in the neighbourhood is that at the Lower Lode, which is worked by Mr. Wintle, of the Llanthony Brickworks, Gloucester.

At the Lower Lode the alluvium is dug to a depth of six to eight feet, is tipped to form a heap, spade-tempered, moulded on the *slop* plan, dried in open-air hacks, and burnt in *Scotch kilns*, of which there are three. The bricks made are principally used in Tewkesbury and the neighbourhood. Agricultural drain-pipes of two, three, four, and six inches internal diameter are made, the alluvium for this purpose having to be worked up in a pug-mill.

This pug-mill is interesting. It is a wooden tub, with an ejection-hole opening into a sunk trough below, from which the pugged alluvium is taken out. A view of this pug-mill is given in Pl. II., fig. 1. In the centre of the tub is a revolving vertical shaft, to which are attached horizontal and cross-knives. The shaft is revolved by a yoke-arm, one end of which is balanced with a block of bricks, while the other end has the yoke-arm attached, which fits over the horse's back. The pugged clay is then put into a box-like structure, and pressed through a die—the necessary lengths of pipe being cut off as the green clay tubes are expressed. The alluvium suitable for pipe-making is a little

stiffer than the ordinary top-stuff, and is not always available.

From the Lower Lode, the walk down to the Haw Bridge is very pretty, the flat meadows and numerous abandoned, but now osier-planted,* pits affording telling evidence of the extent and thickness of the alluvium.

Formerly there were pits by the river-side at Ashleworth Ferry and Sandhurst; but the next one now in work is Tandy's, at Walham, where there is also another worked by a Mr. Dean.

Tandy's Brickworks, Walham, Gloucester.—Here, five feet of brown, sandy alluvium is seen above six feet or more of more clayey material, of a bluer colour. The alluvium is thicker, of course, but below about eleven feet is said to be "not so good," and is therefore but little dug. At this pit most of the bricks are hand-made, but recently a small pug-mill (without rollers above, and worked by a portable engine) has been installed, and wire-cut bricks made.

Llanthony Brickworks, Gloucester.—At this pit of Mr. Wintle's about eight feet of alluvium is dug. The alluvium is very mild, and, as usual, is dug generally during the winter, spade-tempered, moulded without the intervention of any pug-mill, and burnt in Scotch kilns. It is not sufficiently stiff for making drain-pipes, but formerly a more suitable deposit was worked near the present entrance to the works. The reason given here for no agricultural drain-pipes being made now is that "all the agricultural draining seems to be done." No plain- or pan-tiles are made here now, nor, to our knowledge, anywhere on the Severn-side.

Chepstow.—The Rev. Walter Butt informs us that "there are disused pits [in the Alluvium] just above Chepstow Bridge, where I am told bricks were made some 20 years ago."

*The growing of osiers in the exhausted pits and low-lying ground is an important riverside industry, Bundles upon bundles are sent away, but many rectangular baskets are made in sheds on the spot. The industry may be advantageously studied at a place between Deerhurst and the Haw Bridge, where a considerable trade with Birmingham firms is carried on.

II.—OXFORD CLAY.

GENERAL.—In Gloucestershire the Oxford clay occupies only a very small area, and that in the neighbourhood of South Cerney, to the south-south of Cirencester. Here it has been worked for making into bricks in two pits, one of which was situated close to the canal at Cerney Wharf, and the other at Shells Grove, close to Siddington House. Neither of these pits is in work now.

In the Geological Survey Memoir on *The Jurassic Rocks of Britain*, vol. V. (1895), p. 36, it is stated that the brickyard "east of Shells Grove" showed "blue, sandy clay." Mr. A. W. Anderson, of the Stonehouse Brick and Tile Co., Ltd., has very kindly informed us, in response to a request for information, as follows:—

Siddington.—"The brickyard at Siddington was last worked (not by us, but by another party) under the title of the 'Cirencester Brick and Tile Co.,' for a period of about five years, but was closed in June, 1904, as it was found impossible to compete successfully in quality and prices with bricks supplied from Stonehouse by rail. The material is of a very sandy nature, and contains a large percentage of soluble salts, which is a great disadvantage in earths for brick-making purposes. The bricks were made by a wire-cut machine, and burnt in two open Scotch kilns. Owing to the facilities for conveying bricks and tiles about this county by rail and road traction haulage, the day of small yards appears to have passed."

Between the Oxford Clay and the Fuller's Earth come (in descending order) the Cornbrash, Forest Marble and Great Oolite proper. The Forest Marble consists usually of two clay-beds with a median limestone-mass, which, in days past, in Wychwood Forest, was worked and polished for "marble." In the neighbourhood of Taynton, near Burford, clay-beds make their appearance in the Great-Oolite proper; but neither Forest-Marble nor Great-Oolite clays have been worked, to our knowledge, in Gloucestershire for brickmaking. Good enough for puddling purposes, they would probably be too calcareous for brickmaking.

III.—FULLERS' EARTH.

The Fullers' Earth is a clay-deposit which comes between the Inferior and Great Oolites. It is, as a clay deposit, only about a foot thick in the neighbourhood of the Rissingtons, between Bourton and Burford; but between 70 and 80 feet thick at Stroud, and 148 feet at Bath. Its presence can, usually, be easily detected; but at present we know of only one place where it has been dug for brickmaking, and that is at the western end of Selsley Ride, on the left-hand side of the road to Frocester, almost immediately after leaving the Common on Selsley Hill. We have no information to hand concerning it beyond the fact that it was worked up to some thirty years ago, and that probably the clay was found to be too calcareous.

In Somerset and Dorset, however, the Fullers' Earth has been dug for brickmaking, as the following notes by Mr. H. B. Woodward, F.R.S., show:—

"Fullers' Earth clay has been used for brick-making, and burnt for ballast, at Powerstock. Bricks and tiles are made from it near Broadwindsor, Crewkerne, and Bradford Abbas. At High Cross Hill, between Haselbury and East Chinnock, red and mottled, or yellowish tiles, drain-pipes, and bricks, are manufactured. Bricks, drain-pipes, and coarse earthenware were formerly made from the Fullers' Earth clay, west of Newbury, north-east of Mells; but the bricks, as I was informed by the Rev. George Horner, were of inferior quality. The clay is usually calcareous, and often contains racy nodules" (Mem. Geol. Surv., *The Jurassic Rocks of Britain*, vol. iv., 1894, p. 492).

In the Inferior Oolite, which underlies the Fullers' Earth, there are in the North Cotteswolds, and on the Cleeve Hill plateau, some beds of clay, which have been called the Blockley and Snowhill Clays. They are important in places, in connection with the water-supply; but not as regards brickmaking.



PIT IN BASAL UPPER-LIAS CLAY, WOTTON-UNDER-EDGE

IV.—LIAS.

The Lias underlies the Inferior-Oolite limestone, which caps the edge of the Cotteswold Hills. It composes the lower portion of the slope of the Cotteswold Hills and valeland in the Cheltenham, Gloucester, and Dursley districts, and stretches right away to the line of the Severn; but to the south of Purton Passage it forms only a comparatively narrow band between the older rocks of the northern part of the Bristol Coalfield and the Oolites of the hills.

In Gloucestershire, as elsewhere where properly developed, the Lias is divisible into three stages—an Upper, Middle, and Lower.

The top-bed of the Middle Lias is called the Marlstone. It is a hard bed of rock, and being harder than the clay-deposits above and below, usually gives rise to a noticeable platform, which is oftentimes dissected to form tabulated spurs. These spurs are generally fairly easy to locate in the hill-flanks, and the hamlet called "The Quarry," near Dursley, is built upon one that is particularly prominent.

The deposit between the Marlstone and the Oolite is called the Upper Lias, and is present throughout the Cotteswold Hills. It is mainly clay in the northern portion of the county—that is, from Birdlip, northwards; but sand in the southern—from Birdlip southwards. In the southern portion of the county the bottom-portion of the Upper Lias is eminently suitable for pottery and pipe-making, being an excellent mild earth, practically free from "knots" (little nodules); but in places in the northern portion, as at Leckhampton Hill, Cheltenham, it is the topmost portion to which this remark is applicable.

The Middle and Lower Stages of the Lias are thus sub-divisible on lithological grounds:—

- (1) Marlstone;
- (2) Sandy Beds, with occasional calcareous-sandstone bands and nodules (Lower *Margaritatus*- and *Capricornus*-Beds);
- (3) Blue Clays, with occasional limestone-nodules; and

(4) Limestone and thin-clay beds alternating.

The Sandy Beds start immediately below the Marlstone (as can be excellently seen at Robins' Wood Hill and Stonehouse), and extend down to the bottom of the *Capricornus*-Beds; but they are more argillaceous in the lower portion, and are encumbered with two or more beds of impure limestone (or calcareous sandstone) and nodules. The best brick-earth is to be obtained by working upwards from above these limestone-beds. As the Sandy Beds are relatively porous, and the Blue Clays correspondingly impervious, springs and damp ground will indicate their junction; while the upward extent of the former will be shown by the growth of gorse-bushes, for gorse-bushes are fond of a sandy soil, and are a true index thereof.

As showing that the top-portion of the *Capricornus*-Beds and the Lower *Margaritatus*-Beds constitute the best natural brick-earth in this county, it may be mentioned that Messrs. Jefferies' pit at Stonehouse, the great pit belonging to the Stonehouse Brick and Tile Company, also at Stonehouse, those at Robins' Wood Hill and Aston Magna, are all in it. In the neighbourhood of the Mickleton Tunnel, in the North Cotteswolds, it is very easy to see where a pit could be opened, if one is ever required, and for many reasons the site would be an ideal one. Pits formerly in work in the *Capricornus*-Beds were those near Wotton, Pilford (Cheltenham), and Dumbleton; whilst that at Greet is still intermittently worked for supplying the Greet Potteries.

The Blue Clays contain many irregular bands of limestone in their lower portion; but, higher up, scattered nodules take their place. In the top-portion, however, the limestone-nodules increase in number again, and when denudation makes them appear close to the surface, their presence there renders the associated blue clays more permeable to percolating waters. The finely-desseminated iron-pyrites (FeS_2), which is thought to give the blue colour to the clays, when oxidised, produces iron-oxide and sulphuric acid. The sulphuric acid doubtless acts upon the lime-carbonate (which

is present in the clay in the form of fossil-shells, &c.), and produces the crystals of selenite which are of such common occurrence; while the iron oxide is hydrated to form the yellow compound, which causes the clay to be yellowish near the surface.

The nodules of carbonate of lime are very troublesome to brick-makers, and must be either picked out by hand or crushed between rollers. They must on no account be allowed to pass, for, if they are, when the brick is burnt, they will *blow* or fracture it. Badly-made bricks are often seen in garden-walls, with little white nodules in them. These nodules, originally of carbonate of lime, have been reduced, on burning, to lime; and on exposure to moist air combine with the carbon dioxide of the atmosphere, expand, and crack the brick. The Blue (Lias) Clay is also too pure (or, as brickmakers' technology has it, too "strong") by itself for brickmaking, and therefore difficult to mould into bricks and dry without the green bricks getting distorted. Also, when burnt, the bricks are not of a very good colour, and have salts in them which effloresce, forming a white, patchy incrustation on their surface.

So, unless a considerable demand for such a class of brick be assured beforehand, it is undesirable to attempt to make bricks out of the Blue (Lias) Clays: and in support of this remark many instances might be quoted where financial disaster has followed the attempt.

On the other hand, if sand is available for mixing with the clay, as at the Battledown Brickworks, Cheltenham, a very good brick can be produced, for the sand and clay can be combined in the correct proportions. If it were necessary, therefore, to open a brickworks in the Vale, a spot should be selected where sand belonging to the Superficial Deposits is handy. There are many such places.

The lowest lithological division of the Lias calls for no comment here. It is of more interest to those interested in building and road-metalling operations; but it may be as well to mention that the rise along which the Coombe-Hill-to-Tewkesbury Road runs is formed by the outcrop of its limestone-beds, and that all

through Gloucestershire this ridge can be easily traced.

Details may now be given of the various Pottery and Brickworks in Gloucestershire where Lias Clay is dug, and made into bricks or pottery, with or without the admixture of milder earths. They will be discussed from south to north, and, as will be well understood, in order to make the account of each Works complete in itself, some recapitulation of geological facts or manufacturing process is unavoidable.

Wotton-under-Edge.—In the neighbourhood of Wotton-under-Edge there is only one brickworks in work, and that is located off Gloucester-street. The workings are situated, geologically speaking, towards the bottom-portion of the Upper Lias, the clay being sandy, micaceous, brown, and bluish-grey, and remarkably free from nodules. It is probably of about *bifrontis* or *lilli* hemera, for crowds of ammonites of the genus *Harpoceras* were obtained from drain-excavations in the part of Wotton called Old Town, which is on about the 300-foot contour-line, and therefore at a slightly lower level than the bottom of the workings under discussion. (See Pl. II.)

The brick-earth is very similar to that which is used so successfully at Cranham for pottery-making. It is dug, and allowed to weather, then ground in a horse-worked clay-crushing and grinding roller-mill, after which it is passed through a pug-mill, which is made up of a strong iron cylinder, provided with two mouth-pieces for the discharge of the pugged clay, and a revolving vertical shaft, with short knives, and worked by means of a horse, with the ordinary yoke-arm. The bricks at present made are wire-cut, and of the quality known as "seconds." Agricultural drain-pipes are made, and, formerly, roofing and paving-tiles as well. Most of the bricks used in Wotton and the surrounding district come from Stonehouse, as the local bricks that are at present made are scarcely good enough for house-building purposes, so there appears to be ample justification for the development and improvement of the local works. Probably very good pottery could be

made here, like that manufactured at Cranham.

Potter's Pool, near the Church, derives its name, not from the occurrence there in the past of a pottery, but from the fact that the water was ponded back to form a head of water capable of working the mill there that was once owned by a man named "Potter."

Immediately to the south of Hack Mill, however, there was formerly an extensive brickworks. The main pit was situated in the bank on the west side of the brook; but there were also workings near the cottage east of the houses that are marked above the words, "old brickyard," on the 6-inch map (Sheet LVI., S.E.). The brick-earth worked belonged most likely to the *Capricornus*-Beds. Most of the bricks which were manufactured here were thinner than the average-sized modern brick, being only two-and-a-half inches thick. A large quantity of these was apparently produced, judging by the number now seen in the old houses in Wotton.

Lightpill, Stroud.—On the west side of the railway at Lightpill Mills is a small, disused brickworks, with workings that expose the top-portion of the Middle and the bottom-portion of the Upper Lias. The Middle Lias deposits exposed are brown, sandy marlstones, useless to the brickmaker; while the Upper-Lias deposits are clays of a pale, whitish-yellow tint, calcareous, with three bands of nodules (containing specimens of *Dactylioceras* and *Belemnites*), bound together by tufaceous material at the base; and scattered, similarly-coloured limestone-masses (with specimens of *Harporceras* common) in the upper portion.

The brick-earth that was dug here was the Upper-Lias clay. It was put through rollers and pug-mill of similar construction to those used at Dudbridge, and the green brick was burnt in a roofed Scotch kiln, similar to those at Rodborough and Lansdown, Stroud. The finished product was a cream-coloured brick, the colour being attributable to the amount of lime in the raw clay.

Holcombe, near Nailsworth.—Mr. G. W. S. Brewer, F.G.S., of Nailsworth, informs us that clay-pits were opened in the bottom-portion of

the Upper-Lias about a hundred years ago, near the Avening Road, close to the Weighbridge Inn, for the purpose of providing material wherewith to make bricks for use in the construction of the garden-walls of Holcombe House, and for parts of Holcombe Mills. The field near the Mills is still called the "Clay-Pits."

Harper's Brickworks, Rodborough, Stroud.—At these brickworks, bluish and brown, fine-grained, loamy clays, passing up into more sandy beds, are worked. These deposits are Upper Lias; but no fossils have been found wherewith to date them precisely. The clay is so loamy and free from "knots" (or small nodules) that there is no need to grind it with rollers, and it is put directly into a small horizontal pug-mill, from which it is forced through a die in the usual oblong mass, off which green bricks are cut by a wire-frame—as is the general rule—ten at a time. They are then dried and burnt in a roofed Scotch kiln, similar to that at Lansdown, Stroud.

Lightpill Brickworks, near Dudbridge.—This brickworks is often referred to simply as "Lightpill." It is situated, as Edwin Witchell has written (*Geology of Stroud*, 1882, p. 17), "between Dudbridge and Lightpill Mills," and the pit affords a view of some very interesting beds. At the top is yellowish, very micaceous, rock, which weathers, in the clay-getters' language, "like powder." In this condition it looks uncommonly like Cotteswold Sands; but where fresher, it is seen to admit of subdivision into three beds, as at Lightpill proper, and here, as there, but to a more noticeable extent, pentacrinoïd ossicles (or "joints," in the form of external casts) occur in the more nodular masses in the bottom portion of the bed.

Between these sandy rocks and the first band of *Margaritatus*-Marlstone is something like thirty feet of bluish-grey clays. The greater portion of the face of these is hidden by talus. The marlstone-bands have in their upper portion peculiar, flat, pebble-like bodies, and are embedded in a matrix rich in well water-worn pentacrinoïd ossicles and shell-debris—phenomena obviously indicative of pauses in

sequential deposition and penecontemporaneous erosions.

The clay-deposit between the marlstone-bands is bluish, and more clayey (or "longer," the clay-getters say) than that below the lower band, and bricks made solely of it shrink very much—sometimes as much as half-an-inch. On the other hand, the clay referred to above as below the lower marlstone-band is too loamy of itself, and has to be mixed with the "longer" stuff.

The same type of machinery is used here to make the bricks as at the Standard Brickworks, only open-air hacking is resorted to for drying purposes, and the well-built kiln is heated by flues underneath.

Dudbridge, near Stroud.—This brickwork is situated alongside the railway, on the road from Rodborough to Dudbridge, and is called "The Standard Brickworks, Dudbridge." A considerable tract of ground has been levelled by clay-getting operations. The clay dug is bluish-grey in colour, weathering yellowish, and contains numerous pale bluish-grey, oft-times very rounded limestone-nodules, which are frequently septarian in structure. Pentacrinoid ossicles constitute the commonest fossil of these nodules, but *Amaltheus Stokesi* is not infrequent in them as well.

Originally, the bricks at these works were made by hand; but when, in 1872, they were taken over by the late Samuel Jefferies, machinery was installed.

We are much indebted to Messrs. Samuel Jefferies and Sons for the following information:—"The method of manufacture is that known as the plastic or wire-cut system, and commences with the weathering of clay: that is, excavating the clay during the winter months, and exposing the same to the action of the rain and frost, which adds materially to the quality of goods manufactured, and also saves a great deal of expensive machinery. In weathering, the various kinds of clays are mixed or blended, and, after lying out from three to four months, are passed through a series of crushing-rolls into a horizontal pugmill, where it is thoroughly mixed and forced through a steel-lined mouthpiece, from

which it is expressed as an oblong mass, and delivered to an automatic brick-cutting table: an invention of the late Mr. S. Jefferies, and the first machine of its kind to be brought into practical use in this country. The bricks, when severed, are loaded on to cars, and passed through a hot-air tunnel or dryer, the steam to heat which is supplied by the exhaust from engine. This tunnel is about 130 feet in length. At the entrance the heat would be about 40 to 50 degrees, and as they work through this rises to 150 and 170 degrees. When taken out at the bottom end of the dryer they are practically what is called *bone dry*. From here they are taken on the cars to the kiln of the continuous or Hoffman type, the fire in this travelling rom chamber to chamber through the bricks, the dry bricks being loaded in front of the fire, and the burnt bricks taken out after the fire has travelled a sufficient distance ahead. The kind of goods manufactured at these works are high-class wire-cut, engineering, and vitrified bricks: they are used extensively for railway construction, Government buildings, sewage disposal works, chimney-shafts, and, to a great extent, for house-building."

To the south-east of Stroud the Middle Lias floors the bottom of the valley as far as Griffin's Mills, the Marlstones being plainly visible on the north-east side of the canal between Wall Bridge and the railway-bridge near the Stroudwater Dye Works. But from Griffin's Mills, as far as Chalford Station, the Stroud Valley is in the Upper Lias, and pits for obtaining earth for brickmaking purposes have been opened up in it near Brimscombe Station and at the Thrupp, near Griffin's Mill.

Brimscombe.—Mr. W. L. Randall, of the Brimscombe Polytechnic, very kindly informs us, in answer to our request for information, that the Brimscombe Brickworks were opened by the late James Webb, but were acquired along with two other works, namely, that on the Chalford side of Brimscombe Station, and that at the Thrupp by—he believes—Mr. Jefferies, of Ebley, and closed some ten or twelve years ago. Building-bricks were made, and are said to have been very good, and of a soft, agreeable colour. They

were hand-made, no machinery being employed.

Lansdown, Stroud.—At Lansdown, Stroud, is a small brickworks, now abandoned. It was opened by a builder named Harper, continued by a Mr. Walkley, and then taken over by Mr. Baxter, the present (1910) owner. Only bricks were made here; but the earth is too loamy to make a really durable article, and it is obvious that the bricks will not withstand the frost well.

The deposit that has been dug is situated about the horizon of the passage of the Upper-Lias clays into the Upper-Lias (or Cotteswold) Sands, and contains some large tabular "burrs" (about 2 feet 4 inches thick), in which only some obscure fragments of small ammonites were observed. The bricks, which are of a red colour, were burnt in an ordinary rectangular roofed Scotch kiln, with fire-holes in the sides and a drawing and setting wicket at the end.

Cranham Pottery.—At the head of the valley which runs up from Stroud northwards past Painswick and picturesquely situated, partly under extensive woods, and partly on bare common land, is the little village of Cranham. Here Pottery is stated to have been manufactured, with but temporary interruptions, ever since Elizabethan times, and the associations of the locality, its surroundings and the artistic nature of the wares, make one hope that the industry will not soon be discontinued. (See Pl. I., fig. 2.)

One pottery in the village, recently owned by Mr. C. J. R. Stirling and lately acquired by the Cotswold Potteries, Ltd., Leckhampton, is not at present being used, but the other is still in active work and trades as "T. Richings, Manufacturer of the celebrated Terra Cotta for painting [upon, and embracing] flower-pots, pans, etc."

The clay is dug at the back of the owner's cottage, where the wares are sold, and as it is removed the garden is carried forward. The clay is loamy, micaceous, and brown at the top where oxidized, but rich-blue deeper down where unaffected by atmospheric influences. It belongs to the Upper-Lias stage, being mainly of *bifrontis* hemera, and not to the Lower Lias, as Mr. H. B. Woodward (Mem. Geol. Surv., *The Jurassic Rocks of Britain—The Lias of*

England and Wales (Yorkshire excepted), vol. 3 (1893), p. 143) has somehow concluded. Mr. Woodward says he "obtained specimens of *Ammonites striatus* and *Am. Jamesoni*?" from here, but my record of fragments of a *Hildoceras* confirms the original mapping by the Survey Officers and suggests that the specimens named by Mr. Woodward may have been brought from elsewhere, for Mr. S. S. Buckman tells me that they are *Liparoceras cheltense* (Murchison) and a deformed *Acanthopleuroceras subaristiforme* (Futterer). They may have been obtained from Brockworth and brought here.

The little Pottery is very compact, the engine, crushing and pugging machine being in a lean-to shed at one end, and the kiln in the centre of the main building, in which the upper storey functions mainly as a drying-room and the lower as the potters'-wheel room.

In brief, the process employed here is as follows:—The clay is brought from the pit at the back of the cottage over to the Pottery, where it is put through a pair of small, smooth, crushing-rollers, whence it passes into a pug-mill, both of which machines are driven by a semi-portable single cylinder steam-engine. The clay is then stacked out in a shed to stiffen until ready for use on one or the other of the two potters' wheels.

When made the pottery is taken to a loft above, which is heated by the radiant heat from the actual pottery-kiln which is housed in the same shed.

When properly dry it is set in the pottery-kiln mentioned above. The kiln is then closed up and burnt in the usual way. The ware is smooth-looking, pleasing and decidedly artistic, the production of articles suitable for painting on, as vases, etc., being made a speciality and commanding an extensive market—orders being executed for London, Cirencester, Stroud and elsewhere. A glaze is imparted to the interiors, usually of the larger wares, such as washing-bowls (with ingenious pockets for holding the soap) and water-jugs, by coating with red lead and burning.

Atlas Works, Stonehouse.—Both this works and the next to be described are owned and worked by Messrs. Samuel Jefferies and Sons.

The Atlas Works are situated on the main road from Stroud to Stonehouse. The yard dates back to 1860, being the original yard that gained for the bricks from this neighbourhood the name of "Stonehouse bricks." The clay which is dug belongs to the *Capricornus* and Lower *Margaritatus*-Beds and comprises "shale, marl and blue clays, interspersed with marl and sandstone at varying depths." The bricks made here are manufactured on the Wire-Cut system.

Imperial Works, Stonehouse.—These works are alongside the G.W.R. and have sidings connected therewith. They were opened by the late Samuel Jefferies in 1899. The clay dug here is of a superior character to that excavated at the Atlas works, being somewhat higher in the Liassic Series, and goods made of it are of a very rich colour. "The method of manufacture is known as the Plastic or Wire-Cut System, the clay being taken straight from the bank and tipped into a feeder, thence into an edge runner pan with very heavy rolls, from which it passes into a double-shafted mixer, through a pair of rolls and into a pug-mill, whence it is expelled by a screw or a worm through a steel mouthpiece on to a 'Jefferies' Automatic Cutting Table.' Here the column is severed into bricks of the required thickness, the bricks then being passed through a four-track tunnel dryer, and after a period of two or three days come out perfectly dry. These bricks are then burnt in a kiln of the improved Hoffman type.

"The goods manufactured are high-class facing-bricks, wire-cut and vitrified goods (for sewage and paving work), and also terra-cotta goods of an exceedingly rich colour.

"The bricks have been supplied to large Government Works, also for large Railway Contracts, Sewerage, and Engineering purposes."

We are much indebted to Messrs. Jefferies for supplying us with the information given above in inverted commas.

Stonehouse Brick and Tile Co., Ltd.—This limited liability company was organised in 1890 by Mr. E. Jenner Davies, J.P., in conjunction with Mr. J. F. Hayward, of Bath, and the late Mr. M. P. Hayward, of Cheltenham. Mr. Davies is Chairman of the Board of Directors

and has been a director from the time of the Company's formation. He has had Mr. A. W. Anderson as Manager, who, besides planning the works, has run them from the beginning up to the present time. It is now one of the most important works of its kind in the country, and together with a steady but sure improvement in the quality of the goods there has been more than a corresponding widening of the area over which they have been distributed.

The works are close to Stonehouse Station on the G.W.R. and have the advantage of a private siding extending along the whole front and directly opposite the kilns from which the goods are loaded directly into the railway-waggons. The property covers the large hill-side with practically inexhaustible deposits of excellent clay belonging to the *Capricornus* and Lower *Margaritatus* Beds. The clay deposits have already been worked to a depth of 100 feet, and comprise deposits that have received the local names of "Yellow Plastic," "Brown Marl," and "Blue Lias," while, capping the hill, are Midford Sands.

The works as at present constituted are one of the largest in the county, and in point of arrangement and equipment represent the latest and most approved methods in brick and tile manufacture. (See Pl. III.)

The motive power for the main plant is furnished by two large steam-engines by Lees, of Hollingwood, with four auxiliary engines, two of which are by "Robeys," Lincoln, in as many separate departments, and two large boilers, of the Cornish and Lancashire type. The chimney-stack, which was erected in 1900, taking the place of two which were in use before then, is the tallest in the county, having a height of 202 feet, with a base diameter of 17 feet at ground-level and foundation. The chimney is not only connected with the three boiler-fires, but also removes the products of combustion from the entire plant, including eight drying-floor fires and 54 kiln-furnaces. The enormous draught of the chimney may be inferred from the fact that some of the flues leading into it are not less than 700 feet long, and yet sufficient draught is generated for the fires at that distance from the

base of the chimney. The premises are lighted throughout, from inside and outside the buildings, with incandescent gas, and the various rooms are heated with steam; and in every possible way the comfort and efficiency of the workmen have been provided for.

The plant consists of two "Whitehead" wire-cut brick machines. The clay is drawn up an inclined plane from the pit to the upper floor, where it is tipped into the machine. In No. 1 machine it is first of all seized by feeding-knives, which break up the rough lumps, and then fed by gravity into notched crushing-rollers. Thence it is passed through two more pairs of crushing-rollers for still finer grinding, after which it goes through the pugging process in the machine and is passed through steel-lined dies on to the cutting frames, where it is cut up by a wire arrangement into the necessary sizes. The capacity of this machine is about 2,500 per hour. No. 2 machine is similar to the one already described, but has an extra pair of crushing-rollers, is more heavily built, more highly speeded and has a capacity of about 3,000 per hour. The repressing plant consists of one of Pullan and Mann's toggle lever power presses, a "Titley" power press with expanding box for pressing sand-faced bricks, three Whitehead lever represses, and three Sanderson toggle and wheel represses.

The drying plant consists of a drying floor 100 feet by 120 feet, partly heated by fires and partly by exhaust steam, and a "Sutcliffe" six-tunnel car-dryer, the air for which is heated during the day by exhaust and at night by live steam.

The Sutcliffe dryer consists of six "tunnels" each 110 feet in length, in a building 165 feet long, the whole having a capacity for drying 25,000 bricks per day. Each tunnel contains a line of trucks with roller bearings, the track gradient being such that as fast as the trucks of dried bricks are removed at one end the remainder move down to make room for new trucks ready for drying. The heated air, which has a temperature of about 180 degrees, is forced into the tunnels by a powerful fan. From the drying room the bricks are taken, on the same tracks, to

the kilns directly opposite. The kilns, which are in two blocks, are rectangular, having fireholes at each end of the chambers and an arrangement of flues by which the cooling heat is used for drying and warming the goods in the chambers before the fires are lighted.

In the tile department there are two "Sanderson's" tile-making machines, one "Sanderson" repress and one "Whitehead Special" tile repress. The clay for the tile and terra cotta departments is ground specially fine by being put through a "Whitehead" B1 crushing and pugging machine.

The drying-room for tiles is 100 feet by 30 feet, fitted up with tile-racks, and heated by steam-piping above and below the racks.

There is also a terra cotta drying room for plaster mould work, chimney-pots, finials, &c.

The facing-bricks and tiles produced are of a bright light-red terra cotta colour, which is very artistic in appearance, and they have been largely used in the building of first-class residences, railway stations, churches, schools, and public buildings. Many millions have been used in works for the War Office authorities; and one of the first consignments carried by the s.s. *Lusitania* in her trial trips, before she was put into her regular work of crossing the Atlantic, was a small lot of Stonehouse facings and ornamental goods, which she carried to Gibraltar, to be used there for the embellishment of the officers' quarters.

One of the first churches built with the Stonehouse facings was St. George's, Worcester, designed by Sir Aston Webb, F.R.I.B.A., who was the honoured guest of America a short time ago. He used Stonehouse bricks for facing and ornamental work both outside and inside this church.

Vitrified bricks are produced for stable floors and other paving. These are fired to a high temperature, and are similar in every respect to the vitrified bricks used for paving in America.

We are indebted to Mr. A. W. Anderson for much information, and also to the book entitled, *Industrial Gloucestershire* (composed, printed,

and published by Chance and Bland, Gloucester; 1904; price 1s.).

Lower Rea.—This brickworks, abandoned now some thirty years, was opened by Canon Lysons. The clay was found to contain too many limestone-nodules and "gryphites" (*Gryphæa arcuata*) to be suitable for brickmaking, and the works were, consequently, abandoned, but not until a considerable sum of money had been spent on plant and developing the workings. The machinery was worked by horses. At one time there was some suggestion of making a special branch of the canal up to the works. Fortunately, this was not done, but a tramway was constructed instead. The Lias that was worked was of *birchi* hemera, and contained, near the top of the pit, a line of nodules rich in species of *Rhynchonella*, while the clays contained, not uncommonly, the little ammonite, *Arnioceras miserabile*. Beds on the same horizon are exposed at the present time (1910) in the canal banks at Lower Rea Bridge, and at one time a considerable number of bricks were made out of the blue clay that was dug out of the canal and heaped in mounds along its banks. The clay, however, in spite of proper pugging with a horse-worked pug, was found to contain too many limestone-nodules and gryphites to be suitable for the purpose.

Gloucester Gas-Works.—When excavations were made for the foundations of an additional gas-holder, the clay which was dug out was deposited in a heap, and is being gradually used up in the manufacture of bricks. The clay is of *oxynoti-armati* hemeræ, and crowded with small fossils—most of them very interesting.

Robinswood Hill Brick and Tile Works, Ltd.—The works of this company are situated on the south-western side of this well-known hill. The deposit worked for brickearth here comprises the *Capricornus*-Zone, and the basal portion of the *Lower Margaritatus*-Zone. The *Capricornus*-Beds are finely exposed, and comprise bluish, shaly clays in the lower-portion (weather brown), with two prominent bands of fossiliferous nodules, and in the upper portion brown and greyish clays—at certain levels sandy, and at others much more clayey, and of decidedly irregular fracture.

The deposit is on precisely the same geological horizon as that which is worked so successfully at Stonehouse, as a very cursory inspection of the fossils will demonstrate. Some of the blocks, especially from the nodule-beds mentioned above, are crowded with fossils, but their tests have generally decomposed, being now represented by a white powdery material.

We are indebted to Mr. J. H. Jones for very kindly obtaining the following information for us:—

"The works were started eighteen to twenty years ago by Mr. George Whitfield, who laid out and entirely built them, at a cost of about £20,000. Last year they were taken over by a Limited Company, called the Robinswood Hill Brick and Tile Works, Ltd., with every prospect of a good future.

"The output consists of facing-bricks, common pressed bricks, wire-cut bricks, and all kinds of moulded bricks, tiles, ridges, quarries, and agricultural drain-pipes. The motive power consists of two Tinker-Shenton Lancashire boilers, with economiser, and a 150 h.p. high and low pressure condensing engine.

"The common bricks are made in a Bradley and Craven semi-plastic machine, the clay being ground in a perforated pan, then conveyed by means of elevators to a room above, and thence to a mixer, in which water is added, and the clay is made plastic. It is then conveyed to an upright pug-mill, through which it passes, and is forced into the several boxes fixed round a rotary table, which, in turning, brings each box opposite the die-box, into which the clay is passed, under great pressure. The brick is then either stacked in drying-sheds or taken direct to the Hofmann kiln.

"The clay for the wire-cut bricks is also ground, then passed through a mixer, and afterwards through one of Pullen and Mann's machines. The facing and moulded bricks are also made by a Pullen and Mann's machine, but are afterwards hand-pressed.

"The grinding of the clay is a great advantage, crushing, as it does, all the little 'knots' [nodules] which abound in this deposit.

"The tiles and quarries were formerly made on a clot-roller; but it is more suitable to make them on the plastic system.

"All the sheds are heated by coal-fires, and when the bricks are sufficiently dried, they are loaded on small trucks, which are passed on an endless chain down an inclined railway to the 14-chamber Hoffmann kiln, each chamber holding 15,000 bricks, and worked on a regenerative system. The heat, which passes through several chambers on its way to the stack, is regulated by means of dampers, and so partially burns the goods before fuel is added, with a consequent great saving of coal."

It may be mentioned that the Gloucestershire County Council are using (1909-10) the bricks supplied by this firm in the erection of their additional and commodious premises adjoining the Shire Hall, Gloucester.

Brockworth.—There was formerly a brickworks on the north side of the Ermine Street, about half-way between Hucclecote and the Cross-Hands Inn. The pit was in the *Valdani*-Clays; but now the works are abandoned.

Golden Valley, Staverton.—Formerly there were pits by the side of the Gloucester Road, near the Pheasant Inn, Staverton, but now they are quite overgrown.

Cheltenham.—In the neighbourhood of Cheltenham there are only two brickworks in work, namely, those at Battledown and at Hyde near Swindon village. The latter is, moreover, quite a new venture. But in times past pits were extremely numerous. The sites of many of them are, doubtless, forgotten; but some of the works have only been closed recently, and of these it is possible to record some fairly full details.

At *Hester's Way* (near the Mission Room), there was formerly a pit, probably in the *Obtusum*-Beds, which has been filled in with gas-lime. The remains of one of the old kilns can still be seen from the roadway—now converted into a shed. One of the writers has dim recollections of Messrs. Martin and Darby being associated with the Hester's Way yard. North of the present *Harwood Lodge*, near Swindon, there was a pit, now marked only by

a watercress-bed. At the *Cheltenham Gas-Works*, bricks for use on the works have been made out of clay of late *oxynoti*, *rariscostati* and *armati* hemeræ, which was dug near the large gas-holder. The *Folly-Lane Brickworks* are described at a later page. *Messrs Cypher and Sons* grounds on the north side of the Queen's Road, are on the site of a pit that was worked some thirty or more years ago and was probably in the *Oxynotus-armatus*-Beds. Bricks were made of the surface-clay even as far as the Christ Church Road, and in one of the writers' recollection were very limy and salt-scummed.

By the side of the *Leckhampton Road* there were formerly many pits. One of these, which was worked by a man named Thackwell, was taken advantage of when the Cheltenham-Bourton Line was constructed, as by passing through it less making of cutting was necessary. A portion of this pit, which was in the *Valdani*-Clays, has only been recently closed and is that referred to by one of us elsewhere (*Handbook Geol. Cheltenham*, 1904, p. 46) as "at Leckhampton Station." On the Fairfield Estate, now built over, there were clay-pits in the *Valdani*, and possibly earlier zones; and there was also one on the site of the present Leckhampton Reading Room. The *Pilford Brickworks* are described at a later page and so are the *Leckhampton Potteries*. At the corner of Charlton Common, near Daisy Bank, is a small pit in sandy, micaceous Upper-Lias clays which was opened to obtain milder earth for mixing with the *Valdani*-Clays of the Leckhampton Potteries.

Pilford, Leckhampton, Cheltenham.—This brickworks, which was dismantled in June, 1907, was situated at the foot of Leckhampton Hill. The workings are still (1910) in evidence, but probably will be soon obliterated by buildings, for this estate is being rapidly developed. The workings are in the *Capricornus* and basal Lower *Margaritatus*-Beds: the hard bands in the former zone having yielded in the past a rich assortment of well-preserved fossils. For pottery-making some of the Pilford clay is too full of "irony" fragments which make the earthenware black, although until quite recently

the Cotswold Potteries bought a good proportion of their clay from the Pilford Pits.

The works were situated on what was formerly Lady Walsingham's estate and were worked as a brickyard by the trustees, with Mr. G. W. Sadler, at one time Borough Surveyor of Cheltenham, as Agent and Manager. Very good-coloured and regular-sized face-bricks were turned out, and also moulded bricks, tiles and drain-pipes. The common bricks were not very successful (although they were used for the first Ash-Destructor chimney), being commonly supposed to exude salt, and were always more or less damp, and were, for that reason, not very much used in house-building work, as the plaster and paper became discoloured. Some dozen or so years ago the brickyard was purchased by Mr. Councillor E. Lawrence and Mr. C. Williams. They pulled down the old kiln, erected a continuous form of kiln, and installed other machinery, but without any improvement in the quality of the products. Indeed, with the new form of kiln no better goods could be turned out than with the old one, which had been pulled down. At Mr. Lawrence's death the property was transferred to B. W. Pearce and Co., Ltd., who worked it until it was taken over in June, 1907, by Messrs. Webb Bros., Ltd., who dismantled the works, as their Battledown works were of ample capacity for the needs of the town. One feature noticed here by Messrs. Webb was that the water for boiler-work was particularly good, without any purifying process. It apparently contained more iron and considerably less destructive salts than the Battledown water, as the former kept the boiler perfectly clean, while the latter, having up to 70 degrees of hardness, caused a destructive deposit on the inside of the boiler.

The output of bricks at Pilford probably never averaged a million per annum.

The following is an analysis of the Pilford clay:

Silica	62.40
Alumina	13.98
Ferric Oxide (Iron)	9.95
Lime	0.73
Soda, Potash, etc.	6.19
Loss on burning at 400deg. Centigrade	6.75

Total 100.00

Ham Lane, Charlton Kings, Cheltenham.—This brickyard, which was worked by Mr. Marmon, is now closed, but the output was never great and probably did not exceed 200,000 to 300,000 bricks per annum.

The Cotswold Potteries, Ltd., Leckhampton, Cheltenham.—Potteries have long existed near the site occupied by the present works. Under a Mr. Thackwell a large amount of clay was dug out, and near the site of the present Leckhampton Station, and on the old Fairfield Estate (now built over). Later a Mr. Hooper ran the works, and after that they were re-started by Mr. A. Godwin under the title of the "Cheltenham Potteries." A few years back the works were taken over by the Cotswold Potteries, Ltd., who at the same time bought up the Original Cranham Potteries—these however are no longer worked, the business being concentrated under Mr. G. D. Wadham, the Managing Director at Charlton Lane.

The Leckhampton Works are well up to date, and the quality of the ordinary red ware and glazed ware of all kinds is decidedly good.

The ordinary flower-pot is the staple output; but many other varieties of horticultural and other ware, from table knick-knacks (mostly green-glazed with occasional metallic sheen due to the degree of burning of the red lead which forms the basis of the glaze) to rustic stumps or magnificent garden vases are skilfully and artistically turned out by hand. It may be as well to mention, however, that any pattern—say that of a brass bowl—can be reproduced in red ware, and any one desirous of getting a pot or vase to fit a vessel of any particular shape can easily be suited.

The clay, which belongs to the Lower Lias and of *Valdani* hemera, is dug in a small shallow pit close to the works. The top-clay is yellow, and that below blue. The two are mixed together and then ground in a pug-mill, from which the clay issues forth soft and pliant, and of an even yellow colour. From here it is taken to the potters in the adjoining rooms where it is converted by hand on their wheels into the shape required. Gas affords the motive power, a compact little gas-producer supplying a 20

horse power engine. This drives the pug-mill and most of the potters' wheels, but that used for making the larger ware, such as bread-pans, etc., is actuated by a boy. The initial drying is done in the shed in which the potters' wheels are situated; but the kilns and more important drying-rooms are in another building. There are two kilns, which hold apiece from fifteen to twenty thousand pots of ordinary sizes. Before the wares are put in, they must be properly dried, for damp clay cracks very speedily upon being heated. So they are left for some time in the same building as the kilns and in the adjoining shed. Then they are placed in the kilns and subjected to an incandescent heat for nearly three days, when the kilns are allowed to cool and the pots are taken out, the fire alone being responsible for the change in colour from the pale yellow unburnt pot to the bright red finished article.

Battledown Brickworks, Cheltenham.—These extensive works are situated off the Hales Road and at the foot of Battledown Hill. Clay has been worked hereabouts for brickmaking for a great number of years, and it was from pits near if not actually on the site of the present kilns that Sir R. I. Murchison collected the ammonite he figured as *Ammonites cheltensis*.

The main pit or working is on the Charlton Kings side of Hayward's Road, and is in stiff blue Lias clay—so stiff indeed that explosives are often used for its dislodgment. Such clay alone would not have been very suitable for brickmaking; but, fortunately, on the Cheltenham side of the machine-house, is a sand-bed belonging to what geologists call the *Superficial Deposits*. Sand obtained from here is mixed up with the clay, in correct proportions, and a good firm brick is the final result.

The large pit is in the *Valdani-* and *Striatum-*Beds as is shown by the numerous fragments of *Ammonites valdani* and better preserved specimens of *Ammonites cheltensis*, etc. In the upper portion of the *Striatum-*Beds limestone and frequently ferruginous nodules abound, and have to be picked out of the clay. Their presence has made the oxidization of the clays in which they occur easier and consequently they are

coloured yellow by the hydrated iron oxide and have earned for the deposit the term "Yellow Lias." These limestone-nodules are very fossiliferous and a magnificent series of well-preserved fossils may be collected from them.

At the extreme eastern end of the pit, above the Yellow Lias, the clays may be seen to be becoming more sandy and doubtless if the pit were worked back further into the hill the *Capricornus-*Beds with their well-known bluish sandy limestones would be laid bare. The gorse-bushes on the bank above show that the deposit is becoming increasingly sandy and a temporary excavation at the bend of Birchley Road revealed brownish sandy clays with ironstone-nodules of concentric structure. If the pit had been excavated where the gorse-bushes are situated it would probably have been found to be on the same horizon as those worked at Stonehouse, Robins' Wood Hill, and Aston Magna, and formerly at Pilford (Leckhampton). Openings have been made above the top-level of the present pit (in the disturbed ground which can readily be descried), and some portions of "Yellow Lias" have been used for making face-bricks, but the deposit between the good Yellow Lias and the good Blue Lias was found to be useless, being too "rocky." Doubtless it was the basal *Capricornus-*Limestones that were laid bare. They are no good—indeed, a nuisance—and are generally the first portion of the *Capricornus-*Beds to be uncovered. The troublesome layer is, fortunately, not too extensive and it can be removed for ballast burning, etc, and the resultant products of combustion have a ready sale. The clay beneath the sand-deposit in the other pit, on the west side of the Works, also belongs to the *Valdani-*Zone, but is slightly earlier in date than that exposed in the pit on the east side, and is exceedingly good for brick-making. For all practical purposes there is no limit to the clay at Battledown claypits, and the sand underlies all the brickyard to the west of the kilns and extends westwards under Cheltenham. (L.R.)

As regards the actual working of the clay, the gang of clay-getters loosens the blue clay, oftentimes with the aid of explosives, and regularly

by the aid of heavy sledge-hammers and wedges, and then, after reducing the large lumps by means of pickaxes, shovel the raw clay into steel wagons. The steel wagons proceed by their own gravitation, attended by wagon-lads, to the tipping-stage, where the contents of the pit-wagon are tipped on to another wagon, which is promptly hauled, by machinery and a crucible steel wire rope, up a steep incline to the top-storey of the factory, where it automatically tips, in the case of the principal brickmaking machine, into a hopper.

While the last-named wagon is being hauled up by machinery, the pit-wagon, being empty, is taken back to the clay-face by the wagon-lad, to be again loaded for its next journey.

As soon as the clay is tipped into the hopper, it is seized by powerful, hardened, cast-iron revolving *grabber-rollers* and reduced in size, ready to drop into the next pair of rollers, called *kibblers*. Here the clay is still further reduced in size, and falls on to a huge pair of smooth *crushing-rollers*, three feet in diameter; thence on to another pair of similar size, but much more quickly-revolving rollers, which have a gap of but one-sixteenth of an inch between them, and through this the clay is drawn.

By this time, after passing the four successive pairs of rollers, it is rendered fit for the next stage, namely, *tempering and mixing*. This takes place in a double-shafted horizontal *mixer*, of capacity sufficient to hold four Grenadier Guards, with their busbies on. Here the mixing with water and sand, etc., in the proper proportions, takes place, and the softened mixture leaves here for yet another pair of crushing-rollers, set together absolutely "iron to iron." It then falls, a fine, plastic mixture, into the *brick-machine*, or *pug-mill*, a kind of gigantic sausage-machine, where it is still further churned and mixed, and ultimately forced through a die, 10in. by 5in. size. The clay, now an uniform and homogeneous column of brickearth, passes on to an automatic cutting-table, fitted with steel piano-wire cutters, which automatically cut off ten bricks at a time. At its full capacity this machine is easily capable of making 3,000 bricks per hour (equals 30,000

per day, or, say, 150,000 per week, or 7½ millions a year).

The bricks are now made, and in the *green* state, having been virgin clay in the blue Lias only some fifteen minutes or so earlier.

The brickmaking machinery described above is driven by a gas engine and gas-making plant, which makes producer-gas from Welsh anthracite coal by passing a jet of steam and air through the incandescent anthracite in the generator. After passing through various scrubbers and cleaners, the Dowson or producer-gas reaches the gas-holder, from which it is drawn as required by the large Crossley gas-engine (152 i.h.p. town gas, or 137 i.h.p. on Dowson gas). This gas-engine is the largest type of single-cylinder engine made by Crossleys.

Although giving off 137 i.h.p., it is none too powerful for the work it has to do in driving the brick-machine described above, which weighs 70 tons.

The whole equipment is the largest, heaviest, and most substantial brick-machinery unit in Gloucestershire.

Incidentally, it may be mentioned here that the first gas-engine used for brickmaking in England was, it is believed, installed at the Battledown Brick-Works in 1893.

Having now obtained the newly-made bricks in the *wet* or *green* state, they have to be dried, preparatory to being burnt. Three processes are available:—

- (1) Open air (summer only);
- (2) Hot shed floor drying, heated by coal flues, and
- (3) Patent American dryer, heated by steam.

All three are used when the Works are going at full capacity.

In the first two named the bricks are taken off the *cutting-table* on their *palletts* (ten on each pallett, and four palletts per barrow: weight, over 4 cwt.), and wheeled to their drying-place, where they are put down, two at a time, by specially-trained *putters-down*. Open-air drying takes about three weeks, and artificial drying about one week, for the Battledown Lias. In many brickworks, with less susceptible clay, it can be done in twenty-four hours. It is

possible for far more waste to occur in the drying process than in or after the burning.

The fortunate Peterborough clay (Oxford Clay), in addition to requiring no drying, also requires very little fuel, being rich in gas, and the brick almost burns itself. They are thus able to put their bricks on the market at about half the price at which it can be done in the Gloucestershire district.

In the third process the bricks are picked off a patent cutting-table extension, singly, and placed on a double-deck car holding about 620 bricks, which conveys them by portable railway to the tempering room as a preliminary to going into the Special Dryer.

Here they go in at one end *wet*, and, passing through graduated heat, after five days emerge the other end *dry*.

Thence they are taken by the kiln-gang to the kiln-setters, who set or stack them up in the kilns ready for the final process of burning. The burning takes about a week and has to be attended to night and day.

The Hoffman Kiln, which originated in Germany, has a capacity of 280,000 bricks, and is of the continuous type: the fire never (except for bad trade or repairs) goes out, and at least three weeks must elapse after setting the brick before it is accessible as a completely-burned brick. The principle of the Hoffman Kiln is regenerative and continuous. The draught is obtained by a chimney-stack 120 feet high. The air passing through the newly-burned bricks cools these bricks down and is itself correspondingly heated and made ready for combustion in conjunction with the fuel introduced to the chamber of burning bricks. The products of combustion pass forward through green dry bricks and heat them up ready for the fire following in its train. By heating these bricks up, the gases are themselves cooled down and make their escape in the chimney-stack at quite a low temperature, little or no heat being wasted. The draught is under absolute control of experienced burners by means of some 21 dampers, &c. Other kilns known as *down-draught* kilns are also used for special qualities, and when business really booms, as at the time of the

making of the railway to Honeybourne, clamp-kilns are improvised.

The works also include an entirely separate auxiliary gas-plant, gas-engine and brick-machine of capacity, two-thirds of the fore-going raising the total output capacity of the works if called upon to over 10,000,000 bricks per annum. As the total requirements of Cheltenham and district average little more than half that amount the chance of a brick famine in these parts is remote.

Some very good Pottery was made at the Battledown Brick Works in the "Battledown Brick and Terra Cotta Company's" time, that is, before 1888. But exigencies of profit and loss caused their successors to abandon that department of clay-working.

Occasional traces of Lignite have been found in the clay immediately beneath the sandbed mentioned above.

Bricks from these works have been used in building the Cheltenham Town Hall, Lloyds Bank, the Gas Company's viaduct by the well-known world-wide contractors, John Aird and Son, by the Great Western Railway and Midland Railway, and in the recent Honeybourne to Cheltenham Railway. They are taken by traction engine or rail as far as Swindon (Wilts) and Stow-on-the-Wold, also to Bishop's Cleeve, Foss Bridge, North Cerney, Cirencester, Andoversford, Tewkesbury, Kempley (beyond Newent), Winchcombe, Toddington, Rissington, Kingham, (Chipping Norton Junction), Guiting, Brockhampton, Notgrove, Bourton, Shipton, Wychwood, Beckford, Kemerton, Stanton, Broadway, Conderton, Overbury, Bredon, Redmarley, Ashchurch, Slaughter, Witcombe, Gloucester, Sandhurst, Leigh, Oxenton, Northleach, Sherborne, &c.

The following is an analysis of the Battledown clay:

Silica	44.66
Alumina	23.64
Iron Oxide	7.44
Lime	4.35
Alkalies (Potash and Soda)	7.32
Loss on Firing in Kiln	12.59
Total	100.00

Cemetery Road, Cheltenham.—Brickworks have existed on or near this site for many years past: but were closed down in June, 1907, by Messrs. Webb Bros., Limited, who acquired the works.

Professor J. F. Blake, M.A., F.G.S., informed one of us (L.R.: see *Quarterly Journal of the Geological Society*, vol. lxii., 1906, p. 585) that the *Capricornus-Beds* were formerly exposed in the topmost working. That is, beds on the same horizon as Pilford were formerly exposed. This would be in the upper pit or the "Harp-Hill Brickworks"—that formerly worked by Mr. Marmon and now (1910) marked by the skating pond. When last worked the clay was seen, from the ammonites (*Amm. valdani* and *striatus*), to be on the same horizon as that now worked in the large Battledown Pit. The output here was about 300,000 bricks per annum.

The lower pit, that facing the Cemetery Road, was wholly in the *Valdani-Clays* (lower portion of the clays exposed at Battledown), and was worked by the late Charles Winstone as a hand-made yard, with the occasional assistance of horses and a vertical pug-mill. The output in Mr. Winstone's time was probably 300,000 to 400,000 bricks per annum. These two yards were latterly taken over by B. W. Pearce and Co., Ltd., who erected a semi-portable steam-engine and machinery, and, working the two yards together turned out perhaps up to 600,000 bricks per annum. They removed the old clamp-kilns and erected the down-draught, beehive-type of kiln. Messrs. Webb Bros., Ltd., took over these yards in June, 1907, and, as already remarked, have dismantled them.

Folly Lane, Cheltenham.—This brickyard was worked for some time as a hand-made brickyard, in the occupation of J. Yeend, for the owner, Jas. Leighton. Afterwards, it was fitted up with second-hand machinery and a Hoffman Kiln. H. A. and R. J. Webb took the lease of the premises in 1887 and worked it for some five years, and also erected a lime-kiln there. The works were not well equipped with machinery or plant, and the clay was very difficult to work, and very full of limestone-nodules. About 1892 Messrs. B. W. Pearce and Co. took up the lease and worked the pit until a portion of the yard

was purchased by the new Honeybourne to Cheltenham Great Western Railway, when the yard was finally closed.

This Folly Lane pit was open in the days of Dr. Thomas Wright, and he obtained a number of fossils therefrom. The clay was a strong blue clay of *rivicostati* and *armati* hemeræ—somewhat later in date, therefore, than that dug out of the excavations for the gas-holder at Gloucester. It was contemporaneous with that which was formerly dug at Bishop's Cleeve.

Swindon, near Cheltenham: Hyde Brick and Tile Co., Ltd.—These Works are situated half-a-mile east-north-east of Swindon Church, near Cheltenham, and have been in existence about a year, being opened in March, 1909. The pit is in stiff Lias clay, of late *stellaris* and early *oxynoti* date. For the earlier hemera some small gastropods and lamellibranchs constituted the evidence, and for the later ammonites of the genus *Oxynotoceras*. The *Stellaris-Beds* contain numerous little limestone-nodules and occasional specimens of *Gryphæa* and *Belemnites*, and constitute the main portion of the deposit that is worked; while the *Oxynotus-Beds* come on at the extreme southern end of the pit and yielded all small fossils.

The clay is hauled up an incline to the hopper, into which it is tipped; whence it passes through, first, rough grabber-rollers, then smooth crushing rollers; next, the mixer and pug-mill; and, finally, through a die, from which it is expressed in the ordinary oblong pieces, off which a wire-frame cuts the necessary sizes for the bricks.

The "green" bricks are dried in sheds and open-air hacks, after which they are burnt in circular kilns (cupolas).

The Manager of the Works very kindly writes us that "there was such a demand for common bricks last year that it was quite impossible to give any attention to anything else, such as tiles, drain-pipes, etc. We hope to turn out a very satisfactory facing-brick. The Company is, of course, quite in its initial stage, and was begun in a very modest way, as an experiment, till it was ascertained whether or not it was likely to meet with a fair amount of support. As it turned out, we could have sold just four

RESULTS OF EXPERIMENTS TO ASCERTAIN THE RESISTANCE TO A GRADUALLY INCREASED THRUSTING STRESS OF SIX BRICKS, RECEIVED FROM MESSRS. WEBB BROTHERS, LTD., MADE BY MESSRS. DAVID KIRKALDY AND SON, LONDON.

TEST No.	DESCRIPTION.	Dimensions.		Base Area.	STRESS IN POUNDS,		
		Inches.	sq. ins.		Cracked slightly	Cracked generally	Crushed.
P.P. 810 ..	Red Brick (wire cut)	2.96	9.00 by 4.26	38.34	93,000	143,800	143,800
809 ..	Do.	3.00	9.10 by 4.47	40.68	71,500	118,700	127,800
813 ..	Do.	30.6	8.97 by 4.30	38.57	92,000	126,300	126,300
814 ..	Do.	2.98	9.08 by 4.28	38.86	83,800	123,900	123,900
812 ..	Do.	3.02	8.95 by 4.29	38.40	86,500	109,200	109,200
811 ..	Do.	2.98	9.02 by 4.30	38.79	78,000	102,400	102,400
	Mean			38.94	84,233	120,717	122,233
	Lbs. per square inch				2,163	3,100	3,139
	Tons per square foot				139.1	199.4	201.9

RESULTS OF EXPERIMENTS TO ASCERTAIN THE POROSITY OF THREE BRICKS.

TEST No.	DESCRIPTION.	immersion.		Difference	Absorption.	
		Before	After 24 hours'		lbs.	per cent.
P.P. 815 ..	As above.	7.538	8.110	0.572	7.59	6.26
816 ..		7.726	8.189	0.463	5.99	
817 ..		7.968	8.382	0.414	5.20	

times our output had we been able to make them."

Bishop's Cleeve.—Formerly there were several pits where clay was dug for brickmaking in Bishop's Cleeve. The sites of two are still recognisable. "The one is on the road which runs from Cleeve Rectory down to the M.R. Station. It is on the right hand side, and just in front of a new red-brick farm, called 'The Lake Farm.' It is generally filled with water. The other is situated in a field immediately south of the Farmers' Arms Inn, on the outskirts of the village, by the side of the Evesham Road. This is also filled with water." [Frank S. Harvey.]

Greet Pottery, near Winchcombe.—This Pottery, called "Beckett's Greet Pottery," is extremely interesting, and well worth visiting. The clay used is dug at a pit about half-a-mile to the north-west, and is in a deposit of late *striati* hemera, for the clay is becoming decidedly loamy. The clay is carted to the Pottery, and, first of all, is washed in a *wash-mill*. This consists of a circular trough, furnished with a horse-gin, to which are attached two harrows, which, in their passage round the trough, work up the clay, and, as water has been added, produce "a fine pulp." This pulp runs through a *strainer*, and then a shoot, into one or other of the brick-lined, shallow (two to three feet) pits, where it remains until, by evaporation and settlement, it has become of sufficient consistency. Then it is dug out, ground at a one-horse mill, which is fitted with a single pair of smooth, close-set rollers, and falls on a prepared floor below. After this, it is put through a pug-mill, which, in this case, is an iron-cylinder, filled with horse-actuated revolving shaft, with the usual arrangement of knives, and ejection holes for the discharge of the pugged-clay.

The clay, being ready for use, is carried into the shed, and the process is then precisely the same as at the Leckhampton Potteries. The potter, cutting off big slices of the clay, bangs them together with great force, to ensure the removal of any possible air-blisters. This process is called *wedging* the clay. Next, he

works the clay into long rolls, and then breaks off just the quantity required for the making of the pot. He then gets on to his wheel, and commences to create these lumps into a pot.

The potters' wheel consists of a revolving disc: on to this the lump of clay is thrown, and the thumb (potter's thumb) is pressed down to the bottom of the lump, and then, with both hands, he gradually draws it up until it reaches his gauge, when he knows the pot is of the correct height and width. The whole construction thus far being accomplished by hand, is finally smoothed by a small flat piece of iron, called a *plane*, and then, while the wheel is still revolving, by placing a thin piece of wire under it, it is cut from the disc, and deftly caught in the hands of the potter, and placed on a board, about six feet long. When as many others have been turned on the wheel as the board will hold, the lot are conveyed, shoulder high, to the drying-racks, either in the flue-heated drying-room or to the big floor above the kilns, so that all moisture may be absorbed before they are placed in the kilns for drying. Bread-pans, washing-pans, pitchers, etc., are made, and are partially glazed. The glaze here is a darkish-red, due to the presence of manganese in the glaze. The glaze is swilled round inside the article, after which it is ready for burning. There is one up-draught kiln at this Pottery. Some slow fires are lit at first, and the smoke and heat pass slowly up between the stacked articles. This ensures the removal of all moisture. Then all the fires are lit, and the articles are subjected to an intense heat for about thirty hours before they are withdrawn. Thus, whilst pots are placed in what is called an *up-draught* kiln, in which the fire passes right up through the goods and through the roof of the kiln, flower-pots are placed in what is known as a *down-draught* kiln, in which the fire passes up through the pots, strikes against the crown of the kiln, comes back down again through the pots, and is conducted away up a big culvert and chimney.

Pebworth, near Honeybourne.—These Works have been abandoned some forty years, but the stock was sold gradually. The clay dug was of *Birchi*

hemera, and particularly rich in specimens of *Agassizoceras sauzeanum* (d'Orb.).

Mr. J. M. Dixon informs us that many of the Georgian houses in this part of the county were built of bricks made out of clay dug practically on the spot, the clay-pits being then abandoned.

Aston Magna Brick and Terra-Cotta Works.—These Works, opened in 1901, and closed on April 2nd, 1910, are situated by the side of the Great Western Railway at Aston Magna, a hamlet between Moreton-in-Marsh and Chipping Campden, and have a private siding.

The pit is at the foot of rising ground, and in the *Capricornus-Zone* of the Lower Lias—the same geological zone as that worked at Stonehouse and Robins' Wood Hill. The beds comprise bluish sandy clays below, and yellowish-brown and more sandy beds above, the former with the usual blue sandy limestones so characteristic of the lower portion of the *Capricornus-Zone* and numerous nodules—some very ferruginous. Mr. J. Kennedy, of the Batsford Estate Office, who very kindly furnished some particulars concerning the Works, wrote: "I might add that very thin coal seams crop out occasionally at the bottom depth, at which we are at present (March, 1910) working." These seams are probably intermittent layers of lignite, which are not uncommon locally in the *Capricornus-Beds*. Owing to the sliding down of portions of the face, the actual sequence of the component deposits could not be made out at the time of a visit made in April, 1910, but it probably matters little, for the lithic structure of the clays and limestone-bands and nodules suggests that it is identical with that at Robin's Wood Hill. Many of the blocks of rock are literally made up of the dismembered joints of pentacrinoids, and all the usual fossils characteristic of this zone are quite common, beautifully preserved, and of the usual snow-white aspect. At Robins' Wood Hill pentacrinoid ossicles are very common in many of the nodules.

As regards the Works, they are well laid out, and there is excellent plant for the production



F. Mason, Photo.

STONEHOUSE BRICKWORKS.

of both wire-cut and facing bricks, several circular kilns (or cupolas), and a large rectangular kiln, with drying shed on top. When one of us (R. J. W.) paid a visit to the Works in July, 1905, it was observed that the usual type of pug-die outlet was dispensed with, and *in lieu* of it there were expression-rollers, which forced the clay through the die. The bricks were being made in such a soft state that they were being handled with two-pronged forks, to avoid being disfigured by finger-marks and impressions. The Wolff Dryer was also used here, in addition to hot floors for drying the bricks. The articles made were of a very rich red colour, and were chiefly facing-bricks, roofing-tiles, flooring-quarries, sound-proof hollow partition and flooring-blocks (made of a mixture of clay and sawdust), and agricultural drain-pipes. A good quality engineering brick was made, and some three or four million were lately supplied in connection with the new Aynho to Ashendon Railway Extension.

Aston Magna, Leighswood.—About the year 1901 a pit was opened about a third of a mile away to the south-east of the above-mentioned Works, in the blue clays of the *Raricostatus*- and basal *Armatius*-Zones, but the presence of limestone-nodules and the distance from the railway combined to render the project unprofitable, and it was abandoned. The clays here contain "gryphites" (*Gryphæa*) and belemnites not uncommonly, and small examples of *Microceras subplanicostum* (Oppel) and *Unicardium cardioides*, Phil.; while the limestone-nodules yield *Microceras densinodum* (Quenstedt), etc.

Mr. Kennedy writes: "I do not think that it is the tendency in this district to revert to stone for building houses, certainly not for general work, but, at the same time, houses of any importance that have been built of late years are chiefly faced with local stone, and lined with brick."

Broadwell, near Stow.—The Brickworks at this village are now closed. The pit was in the Upper-Lias clay.

Sherborne.—Bricks and tiles were formerly made out of Upper-Lias clay at a small works on the north side of the brook at Sherborne,

but the yard has now been closed some forty years. It is said that there was too much lime in the clay.

KEUPER MARLS.

General.—Below the Lias is the Rhaetic and below the Rhaetic the Keuper Marls. In Gloucestershire the Keuper Marls occur at the surface over a considerable area, as will be easily seen on reference to a geological map. They are particularly well seen in the river-cliffs of the Mythe Tute (Tewkesbury), at Wainlode, Garden, Sedbury and Aust Cliffs, and inland at the Shortwood Brickworks (near Mangotsfield Station).

The Rhaetic Beds comprise black shales with very thin stone-bands and pale-coloured marls also with stone-bands. In this county they have not been made use of for brickmaking, but at the Glen Parva Brickworks, Wigston, Leicestershire, they are ground up along with the Keuper Marl for that purpose. The bricks here are quite satisfactory as the numerous buildings in the neighbourhood testify.

In Nottinghamshire and Leicestershire the Keuper Marls are extensively worked for brickmaking, but although they occupy a considerable area in the northern part of Gloucestershire, west of the Severn, they are seldom worked. The reason is doubtless that in the area where they occur there is no demand for any quantity of bricks to justify the opening of an extensive yard and installation of heavy plant.

Where they are worked, namely at Taynton, the red clay derived from the marl makes excellent pipes, pottery, and good sound wire-cut bricks.

Some years ago one of us (R. J. W.) inspected some clay-beds associated with Keuper Marls at one of the Celestine Workings near Yate and had a truckload sent to Cheltenham and put through the machine at the Battledown Brickworks and afterwards burnt. The clay was green and reddish-brown and both kinds were particularly good and burned into an excellent brick. The reddish clay made a particularly

good-coloured red brick, and the green clay also made an excellent article, but being burned with the local goods the fire that it was possible to put into the green bricks of the Yate marl was limited. It appeared as if they would have stood far greater heat, even to fire-brick heat. They were very excellent beds of clay from a brickmaking point of view, but the district was away from the railway and rather too far away from any place where the bricks could be largely used, which is fatal to a brickyard from a financial standpoint.

In the Bristol district, on the other hand, where there has been such a demand, several pits have been opened in the marl, but now the works at Cattybrook and Shortwood are the main sources of supply.

Taynton Pottery and Brickworks.—These works are now (1910) run by Mr. H. W. Phillips. The top six feet or thereabouts of creamy yellowish clay, which is derived from the weathering of the Keuper Marls, is wheeled out and weathered, then put through a small machine with rollers and pug and afterwards stacked by to sweat. After this it is used entirely for pottery-making and makes a very excellent article, burning a good red colour.

Underneath the yellowish clay mentioned above is normal Red Marl, which furnishes a clay that is also wheeled away, heaped up and afterwards used for making pipes and common bricks by the usual pug-mill and wire-cutting process. The pipes are dried in a drying-shed, and the bricks on temporary hacks out of doors, after which the bricks are burned in a small rectangular updraught kiln of a primitive type. The wire-cut bricks, which were a good metallic brick but not a very good colour, fetched about 30s. per 100 at the yard and the flower-pots 4s. per cast.

The pipes and pottery were burned in the usual pottery-kiln, round which is built a shed used for the pottery making (in which there are two Potters' wheels), the upper floor of which acts as a drying shed. The pottery is dried in the usual way by radiant heat from the pottery-kiln. The fuel used for the pottery-kiln is coal to start with and wood to complete.

Some little time ago a well was sunk some 40 or 50 feet in the Red Marl, which of course is very thick in this neighbourhood.

Stoke Gifford Brick and Tile Company.—The Works of this Company are situated on the east side of the village. There is an extensive pit in the ordinary red marls of the Keuper, which are lined with greenish zones. The greenish rock is not ground up with the red; but is thrown on one side in the pit.

The red marl is loaded into pit wagons which descend by their own gravitation to the foot of the incline, whence they are drawn up and tipped into one of two perforated dry-pans situated on the ground floor of the factory-building. The crushings are then taken by the usual type of elevation to the top of the building and dropped into a wet pan, where further crushing and mixing with water takes place. The clay then falls from this pan on to the crushing-rollers and thence into the usual straight delivery type of pug and wire-cut table. The bricks are wheeled away to the shed drying-floors, which are heated by exhaust steam from the horizontal steam-engine; are hacked up some five or six feet high with plenty of air-spaces between, so that the warm air shall circulate and dry them; after which they are ready for burning in a Manchester Continuous Kiln. Practically only common bricks are made at this yard and the quality is very good and sound, but the brick has rather a scummy colour. From the kiln the bricks are loaded direct on to the railway-trucks in the siding, which is connected with the recently-constructed new South Wales Direct line (G.W.R.). Most of the bricks, we were told, are sent to South Wales *via* the Severn Tunnel.

Shortwood, near Mangotsfield.—These works were acquired by the Cattybrook Brick Company about five or six years ago, who spent a considerable sum of money upon structural alterations and in improving the machinery in order to bring the process of manufacture more up to date and in line with the methods so successfully employed at the Cattybrook Works. The large face of red Keuper Marl, so conspicuous to the traveller to Bristol on nearing Mangotsfield, is

not worked now; Coal-Measure shales, very similar to those at Cattybrook, furnish the main supply of brick-earth.

The Cattybrook Brick Co., Ltd., Almondsbury, near Bristol.—This Company's Works are at Cattybrook, Almondsbury, and Shortwood, near Mangotsfield, the Head Office being at 1, St. Stephen's Chambers, Baldwin-street, Bristol.

The Works at Cattybrook (Station: Pilning, G.W.R.) are the most extensive in the county and were commenced close upon fifty years ago by the late Charles Richardson, C.E., of Clifton, Bristol, the originator and designer of the Severn Tunnel. Mr. Richardson continued to actively supervise the various manufactures of the Company, assisted by one of his engineering pupils, Mr. Ernest Edwin Street, C.E., who ultimately became Managing Director, and under whose skilful control the bricks, etc., of the Cattybrook Company obtained their present well-known reputation for excellence of quality and colour.

The brickearth now dug at Cattybrook belongs almost entirely to the Coal Measures, but there is a trace of Keuper rock above in all of the pits. The Coal Measure deposits are very steeply inclined and usually very little removed from the vertical. Their prevalent dip is north-westerly, and they comprise mainly layers of shale with several coal-seams, bands and irregular layers of sandstone (with plant remains), while curious reddish clay-ironstone nodules are distributed throughout the whole.

In the Geological Survey Memoir on *The Geology of East Somerset and the Bristol Coalfield* (1876), page 43, it is stated that "in the railway-cutting at Almondsbury and at Cattybrook, coal-seams have been found, one bed being 4 feet thick and burning freely with a white ash. This seam appears to have been worked already (about 1756), from old tokens of the Birmingham Mining Company found there. The seams lie almost vertically." The present Company does not work the seam; but have had to prohibit people taking away any coal as the fire-clay faces were often damaged.

The Coal Measures were of course originally laid down more or less horizontally, but subsequent to their formation were subjected to

crust-pressures, reared up almost on end, and their upturned edges denuded. Then the whole area sank again and the Keuper rocks accumulated on the worn surface of the Coal Measures.

There are three main pits all in the Coal Measures; but in each pit, in some part of the face, the Keuper rocks are to be seen resting almost horizontally upon the highly-inclined Coal Measures, affording an excellent example of what in geology is called an *unconformity*.

The main "claypit" at present being worked is a very great distance from the machinery. The "clay" is obtained by digging and blasting, is carried in wheel-barrows and tipped into trucks which are drawn from the working-faces to the foot of an incline, whence they are hauled by winding drums to the grinding-mill and pan. Thence the clay is fed to the mixer, and finally finds its way to the pug-mill, from which it emerges in a continuous piece of the required consistency, breadth and length, to be cut to the proper thickness by a series of vertical wires. The green bricks are then run, in barrow-loads of fifty bricks at a time, to the sheds for drying, and this having been accomplished they are again collected upon barrows, and taken to the blue and brindle, red, or other kilns for burning. One of the machines in operation is capable of turning out bricks at the rate of 120 per minute.

Owing to their excellence of colour and remarkable durability the Cattybrook bricks are acknowledged by leading engineers and architects throughout South Wales and the West and South of England to be unsurpassable. Red, blue, buff and brindle bricks from the Almondsbury and Shortwood works have been used extensively for some of the largest and most important undertakings, amongst others: The Severn Tunnel, Rhondda-Valley Sewerage, Barry Docks, Monmouthshire Western Valleys Sewerage; and at the Ferndale, Penrikyber, Powell Duffryn, Ocean, United National, Main, and other Collieries; by the Great Western and Midland Railway Companies; for Cheltenham Technical Schools (along with Battledown wire-cuts) and Bedford Grammar School; Gloucester Wagon Company's Offices; Mansion at Toddington; Naunton Park and Gloucester Road Council Schools at Cheltenham, etc., etc.

The Crushing Weights, as made at Kirkaldy's Testing Works, London, are as follows :

Description.	Tons per Brick 9"x4½"x3"	Tons per Square Foot.
Ordinary Common Bricks.	112·8	436·0
Red Pressed Bricks.....	101·0	381·2
White Pressed Bricks....	100·5	393·7
Brindle Vitrified Bricks ..	158·6	631·7
Blue Vitrified Bricks	183·6	729·5
Red Vitrified Bricks	161·5	646·1

The manufacture of red and buff terra-cotta is also successfully carried on at Cattybrook and has been used almost exclusively in the extensive buildings of the Imperial Tobacco Company and of Messrs. J. S. Fry and Sons, Ltd., Bristol; for Corporation Schools (7) and Baths, Bristol; while several Higher Grade Schools, shops, halls, hotels, etc., near London; and at Cardiff, Newport, Swansea, Cadoxton, Hengoed, and other places in South Wales have had this terra-cotta used in them.

[This paper will be completed in the next part of the Proceedings.]

BRICKEARTHS, POTTERY & BRICKMAKING IN GLOUCESTERSHIRE

BY

L. RICHARDSON, F.R.S.E., F.L.S., F.G.S.,

AND R. J. WEBB

(Continued from Part 4).

VI.—COAL MEASURES.

The Coal Measures occur in three areas in Gloucestershire: (1) in the Forest of Dean; (2) under a portion of the Severn Estuary, and (3) in the Bristol Coal-Field.

In Staffordshire, as is well known, very excellent bricks indeed are made from the Coal Measure clays. The same remark applies to this county, for the Cattybrook bricks are second to none.

Forest of Dean.—In this district comparatively little brickmaking is done at the present time. Some of the reasons for this are, that the building trade is quiet and there are no large centres requiring a considerable quantity or making a steady demand; that bricks are imported from Stonehouse, and to a lesser extent from Cattybrook; and that the transport facilities within the district are not all that could be desired.

Cinderford Brick and Tile Works.—These works are of recent erection, and now that the Wilderness Works are extinct, are by far the most extensive in the Forest. Formerly, a high-class firebrick and building brick, as well as tiles, were produced, but now (1910) only facing and wire-cut bricks are made, the clay at present used being unsuitable for tiles. The brickearth used is the shale over the "Twenty-inch" coal-seam and is exposed in a face 20 feet high, the top five feet being a yellow loam, the next three feet a tough clay, and the bottom 12 feet a grey shale. We are officially informed that the tough clay and shale are mixed for the wire-cut bricks;

while the top yellow loam is used for the red facing-bricks.

Futterhill (or Dark Hill) near Coleford.—Here the fire-clay under the Lower Trenchard Coal-seam was worked, and very good fire-bricks and ordinary bricks were made, along with pans and flower-pots.

Primrose Hill, Lydney.—At Hulks Colliery the Trenchard Clay is used at the present time for brickmaking, and a very good article is turned out, fetching 35s. per 1,000 on the ground.

Soilwell, near Lydney.—Common and fire-bricks are made here from the clay under the Trenchard Seam.

South Mobberley, Cinderford.—Surface-clay, probably belonging to the deposit that occurs beneath the Twenty-inch seam was until recently worked and made into rough pottery and building-bricks.

Staunton.—Between Coleford and Staunton, at Staunton Crossways, is a disused works that was called "Marmion's Brickyard." Here the Trenchard Clay or the fire-clay under the Lower Trenchard Coal-seam was worked, and ordinary and fire-bricks were made, along with tiles and drainpipes. The quality of the articles was fair and the works are generally supposed to have been closed on account of the stone competition, high cost of fuel, and poor transit facilities.

The Tufts, near Lydney.—Here surface-clay was formerly made into bricks, but the small demand, coupled with the difficulties of haulage (bad roads) did not justify proceeding with the undertaking.

Walmer Brickworks, Ruspidge, near Cinderford.—This works, which has now been closed some thirty years, was started by a Collicry Company, when they found that the clay over the Trenchard seam was very admirable for brickmaking. When the colliery ceased working, however, the brickworks was closed.

Bristol Area.—In this area, except for the Cattybrook and Shortwood Works, there are few brickworks of importance deriving their brick-earth from the Coal Measures.

Fireclay and Brick Company, Ltd., Yate.—This company went into liquidation some four years ago, and the property has been acquired by the Wickwar Chemical Company, Ltd.

The clay used by the Fireclay and Brick Company was Coal-Measure Clay, which was mined underground and hauled up through an ordinary colliery-shaft. It made a very fair class of firebrick, although not able to compete with the Stourbridge hand-made article, for it is a well-known fact that in firebrick goods the hand-made article still beats the machine-made brick for fire-resisting work.

At Yate, in 1905, they had a revolving perforated dry pan on the ground floor, into which the stony-like shale lumps of clay from the mine were tipped. After passing through the pan, the ground clay was taken by an elevator to a stationary double-roll wet-pan, thence through rollers and pug to the cutting table. The best goods were hand-slopped after the clay had been tempered by machinery. All the old and waste firebricks were reground in a dry pan and mixed with clay. The rest of the plant was a 20 H.P. steam-engine, round down-draught kilns, and exhaust steam-heated floor.

Bristol Brick and Tile Co., Ltd., Crofts End Road, St. George.—Mr. E. C. White, the Managing Director, informs us that "our clay-pit contains marls, Coal-Measure clays, such as fire-clays and bastard fire-clay and plastic clay." The machinery used in manufacturing comprises Whittaker's Perforated Grinding Mills (dry pan), Wet Mixer, and Davis's Brick-making Machine, with Continuous and Bee-hive Kilns. The drying-floors are heated by exhaust steam from the engine. The capacity of the plant is 8,000,000 per annum. All kinds of bricks, tiles, creases, pavings, etc., are manufactured, and any pattern bricks are made specially to order. Wire-cut stock bricks are a speciality, and tests made at Kirkaldy's Testing Works, London, show:—

Crushing strain: 638·1 tons to the square foot.

Average absorption: 3·32 per cent.

Fishponds Brick Co.—The works of this Company are now closed; but at one time

appeared to be doing excellent business, producing all kinds of common pressed and ornamental bricks in buff, blue and red. The plant appeared to be good, and a Wolff Patent Ironclad Dryer was used for drying the best wire-cuts. A good article was manufactured and apparently a good price was obtained for the goods.

Stanley Park Brick Co., Ltd.—The works of this company at Staple Hill are also closed, and the buildings have been demolished. In 1905 a good-looking common red brick and quarries were manufactured by means of a Whittaker dry pan, piano-wire screen table, shafter wet mixer, and a straight delivery pug.

Crew's Hole, St. George's.—These works belong to the Bristol Fireclay Company. All kinds of terra cotta work, drain pipes, chimney pots, etc., are manufactured.

Croft's End, St. George's.—At Brook End Messrs. G. E. and A. Fussell have a brickworks at which stock bricks and squares are produced.

Other works in the Bristol area are those at Chester Park, Kingswood; Mount Hill, Kingswood; and Warmley—all kinds of sanitary work being a speciality at the last-mentioned works.

VII.—OLD RED SANDSTONE.

At certain horizons in the Old Red Sandstone, and especially near the base, deposits of marly clay occur, which at a few localities have been dug for brickmaking. The clay, however, is often far from suitable for the purpose under consideration.

In Gloucestershire we know of but three localities where the attempt has been made, namely, at Clifford's Mesne (near Newent), near Hope Mansell (near Mitcheldean), and, nearer Mitcheldean still, at the present Wilderness stone-quarries.

Clifford's Mesne.—At Clifford's Mesne there is an old pit in which the basal Old Red Sandstone marls and Downton-Castle Sandstones are exposed to view. These brickworks were opened in 1895, but the Old Red marls made so strong a

clay that it would not stand burning, and so the works were abandoned in 1898. The bricks that were made were of an extraordinary red colour, but were only used locally, although those used for paving are said to have been of a decidedly good quality. The machinery used was a round stone and a pug-mill.

Hope Mansell, near Mitcheldean.—A brickworks was formerly in work in the Old-Red marls in the wood to the east of this village, but was abandoned, partly owing to the strong nature of the clay, and partly to the increasing thickness of the overburden, as the workings were extended in an easterly direction—the beds dipping more or less in that direction and sandstone coming on.

The Wilderness Brick Co., near Mitcheldean.—Red marls, associated with the Old Red Sandstone, were formerly dug for making bricks and terra cotta articles at the present Wilderness Quarries. The terra-cotta articles included flower-stands, etc., while among the bricks a very excellent type of facing brick was produced. Large numbers of these were at one time sent into Cheltenham. The bricks were made either by the semi-dry or semi-plastic process.

VIII.—SAND-LIME BRICKS.

Vide Proc. Chelt. Nat. Sci. Soc. vol. i., pt. 3, pp. 199-202.

CONCLUSION.

It is hoped that the information contained in this article will be of interest and value to not a few. A brickworks, to flourish, must be near a railway or a satisfactory market, and both if possible. Gloucestershire is well provided for in the matter of brickworks: the largest are those at Cattybrook, Shortwood, Stonehouse, and Battledown (Cheltenham).