

Bricks and Brickmaking

Many people outside the building industry will be surprised at the number of varieties of bricks; the regional variations depending on geology, the methods of manufacture and the uses. This book gives an insight into these, with a brief history of brickmaking, descriptions of moulding by hand and by machine, drying, the use of kilns and firing. The Romans introduced brickmaking to Britain and the industry was revived by Flemish craftsmen in East Anglia in the early middle ages. Until the early nineteenth century bricks were made in numerous small brickyards supplying local needs but then demand for bricks led to the invention of new brickmaking machines and improved kilns which enabled clays to be used that were previously thought unsuitable. Since the Second World War brick has had to compete with many newer building materials but still holds its own as a facing material. Today traditional methods still survive in the smaller yards.

Martin Hammond studied architecture at Nottingham University and the City of Leicester Polytechnic and is now an architect in Bournemouth, Dorset. He is a member of the British Brick Society, which studies the history of bricks and brickmaking. He collects old bricks and makes wood-fired bricks and tiles at Park Farm Museum, Milton Abbas, Dorset. He has advised on restoration work at the Blists Hill brickworks site, Ironbridge Gorge Museum, Baumber Brickyard and Powerstock Common. He has also contributed an article to *Industrial Archaeology Review* on the development of brick-kiln design.

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Bricks and Brickmaking

MARTIN HAMMOND

BRICKS AND BRICKMAKING

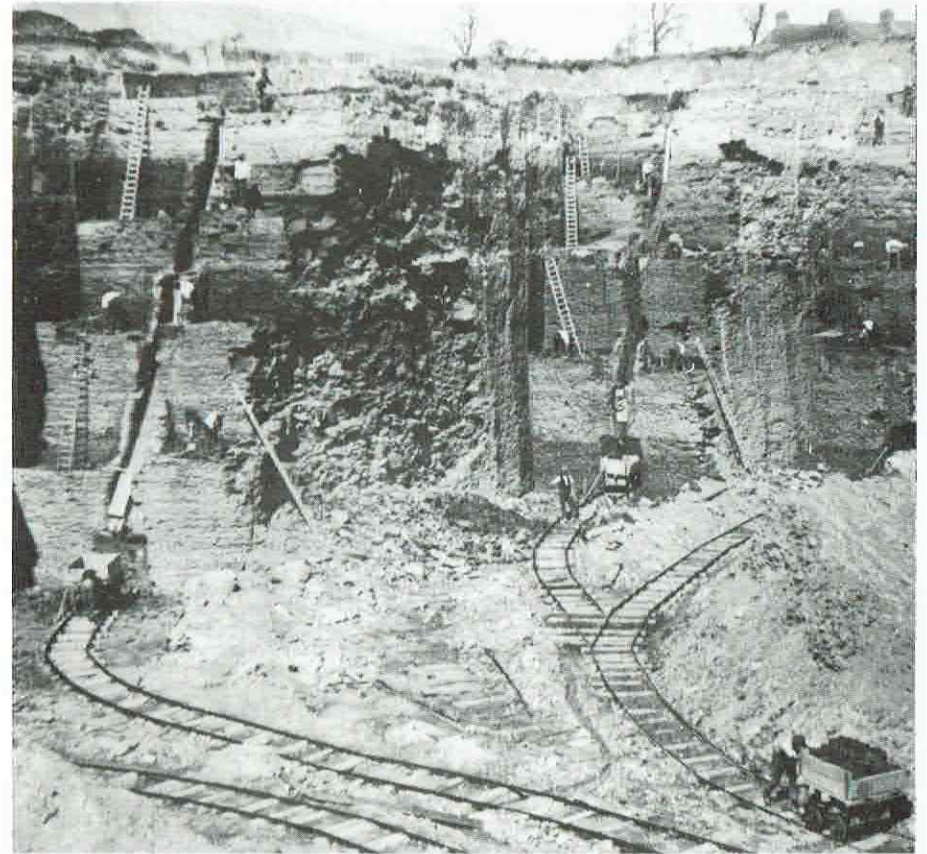
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Digging clay by hand for Fletton bricks, Calvert works, Buckinghamshire, c 1900. The men working at the different levels send the clay down the chute to the waiting tubs.

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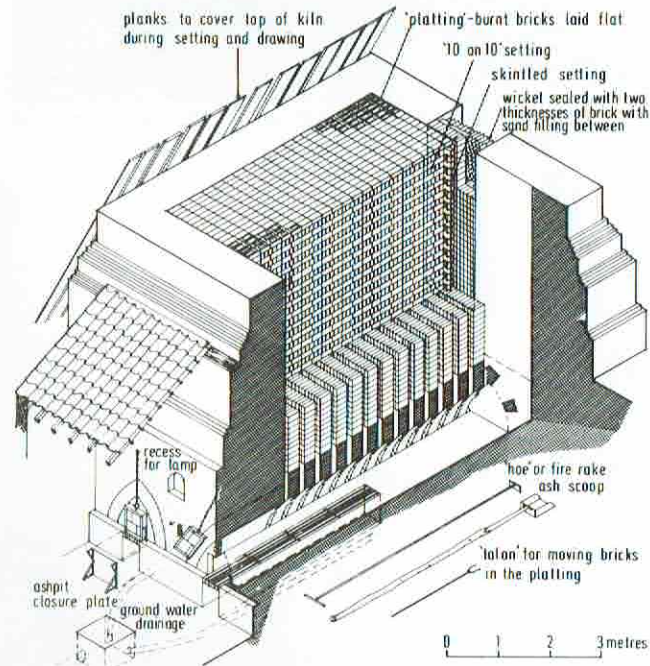
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COVER: (From left to right, front row) Mathematical tiles, an eighteenth-century substitute for facing bricks; seventeenth-century Dutch paving brick; stoneware tie brick for cavity walls, from Poole, Dorset; (second row) smooth perforated wirecut brick from Wellington, Somerset; Burwell (Cambridgeshire) pressed Gault facing; Haunchwood two-panel blue stable paviour; (third row) London stock; Fletton facing; red hand-made facing from Great Melton, Norfolk; calcium silicate brick; (fourth row) Staffordshire pressed blue brick; clamp-burnt Sussex stock; glazed brick from Newton Abbot, Devon; Warnham (Sussex) stiff-plastic pressed common; (back row) perforated wirecut rustic facing; firebrick.



BELOW: Typical East Anglian coal-fired Suffolk kiln. The wicket is shown in the end wall for clarity: normally it was in the side wall.



Horse-operated pugmill, South Cove, Suffolk. Beyond the mill, bricks are drying in hacks under a permanent tiled roof and movable wooden caps. In front of the man is a hack barrow for transporting freshly made bricks to the hacks.

CLASSIFICATION OF BRICKS

Bricks may be described in terms of the clays composing them, the way they are made, or by their purpose or appearance. All these elements have changed from time to time with the use of fresh brickearths, new methods and changes in use and style.

Facing bricks are used where appearance is of greatest importance. Engineering bricks are used where great strength, density and low absorption are required, as in railway structures and sewer construction. Common bricks are used where neither strength nor appearance is critical.

In relation to size the British Standard (1965) of $8\frac{1}{8}$ by $4\frac{1}{8}$ by $2\frac{3}{8}$ inches became metricated in 1969 (BS 3921) at 215 by 102.5 by 65 millimetres. The current standard is BS 3921:1985 'Specification for Clay Bricks'. The metric size is retained, but three forms are defined: frogged, perforated, and solid, as are measures of frost resistance and soluble salt content. These are crucial for determining the suitability of bricks in different applica-

tions. BS 187 covers calcium silicate bricks and BS 6073 deals with concrete bricks.

British Standard 4729: 1971 gives dimensions of a range of special shapes developed during the last hundred years. Few specials as we know them were made before 1850.

Certain types of bricks which were made in a particular locality or which have certain properties have become familiar to generations of builders. Blue bricks are made from a clay found in the Coal Measures of Staffordshire and the West Midlands, which contains about ten per cent iron oxide. The high firing temperature and the oxygen deficiency in the kiln reduce the oxide to iron.

Fireclays, also found in the Coal Measures, just below the coal seams, are made into firebricks and a wide range of hand-moulded and pressed special shapes. The best firebricks were made at Glenboig in Strathclyde, Stourbridge in the West Midlands and in Wales and South

Yorkshire. Glazed bricks were pressed from lower-grade fireclays and dipped in pottery-type glazes before firing. Alternatively, salt was thrown on to the fires at the height of the firing. It vaporised and formed a brown glaze on the exposed faces of the bricks in the kiln.

The yellow London stocks were made from a slurry of London Clay, ground chalk and water, dried out in *settling ponds* or *washbacks* and mixed with sifted town refuse. They were hand-moulded, dried in *hacks* and burnt in *clamps*. Millions of them were made in semi-permanent works around the Thames estuary and the outskirts of London. They are now machine-made by the *soft-mud* process.

From the seventeenth century onwards architects ordered rubbers, which could be gauged to allow minimal mortar joints in

the arches of windows and doorways. They were made of sandy red clay, well burnt, and were rather larger than ordinary bricks to allow for rubbing and cutting to shape. The last works to make them, at Bracknell, closed in the early 1980s. They were hand-moulded from local clay, dried in unheated sheds and burnt in a coal-fired downdraught kiln, protected from the greatest heat by the firm's facing bricks.

From 1882 the Lower Oxford Clay was exploited at Fletton near Peterborough. Common Flettons are cream to pale pink, with darker *kiss-marks* where they touched in the kiln. They have a deep V-shaped frog or panel in the top of the brick. The London Brick Company, now the sole maker of Flettons, applies sandblasted finishes to match most traditional types of facing brick.

THE GEOLOGY OF BRICK CLAYS

The era, period, age (in millions of years before the present) and characteristics of the principal British clays and the time when first exploited are listed below:

PALEOZOIC

Devonian (395-345). Hard *shale*, fireclay: Exeter, South Wales. Nineteenth century.

Carboniferous (345-280). Grey *shale* in Coal Measures: Scotland, northern England, Midlands, Severn estuary. Hard, deep-red bricks. Also *Etruria Marl* for blue bricks and tiles. Eighteenth century.

MESOZOIC

Triassic (215-190). *Keuper Marl*, hard reddish-brown mudstone with thin bands of limestone ('skerry') and gypsum. Nottinghamshire and Leicestershire. Light red and cream bricks, usually wirecut. Early nineteenth century.

Jurassic (190-136). *Lias clays* in the stone belt from Lincoln to Cheltenham. Early nineteenth century. *Oxford Clay*. Bedford and Peterborough Flettons. High carbon content saves fuel in firing. From 1880.

Cretaceous (136-65). *Wealden clay*, mixed with fuel for Sussex stocks. Also at

Swanage, Dorset. Eighteenth century. *Gault clay*, blue-black, burns white. Kent, Dorset, Wiltshire-Cambridge. Often mixed with sand from adjacent beds. Nineteenth century.

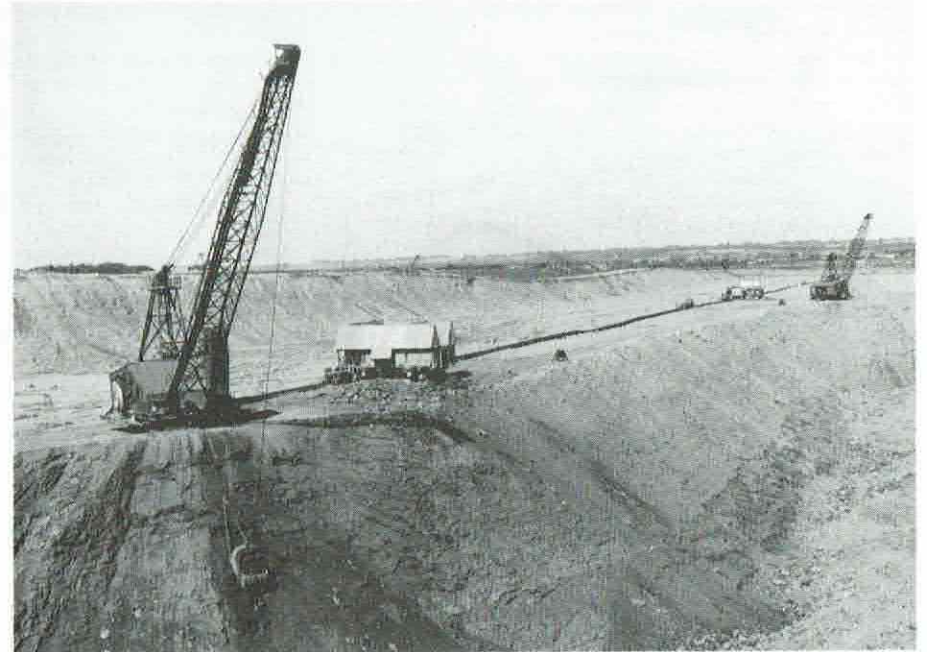
CENOZOIC

Eocene (54-38). *Reading Beds*. Mottled purple and grey clays. Berkshire, Suffolk, Dorset. Seventeenth century. *London Clay*. Stiff blue clay which weathers brown. Suffolk, London, thinning westwards towards Hampshire. Sand added to avoid warping. Late seventeenth century.

Pleistocene (1½-½). *Icenian clays*: east Suffolk. Red bricks. Nineteenth century.

Pleistocene (½-0). Glacial clays and sands: '*Boulder clay*'. Northern England, Wales and east Suffolk. Late medieval. '*Clay-with-flints*'. Hertfordshire-Buckinghamshire border. Nineteenth century.

Holocene (10,000 years to the present). Alluvial clays: Vale of York, Humber-side, Lincolnshire, East Anglia, Thames and Medway valleys and estuaries. Roman and early medieval.



Digging clay for Fletton bricks by dragline excavator. The excavated clay is dropped into a hopper, which feeds a conveyor belt leading to the works.

CLAY WINNING AND PREPARATION

Traditionally most work stopped in the autumn but a few men were retained to dig enough clay for the next season. They used narrow-bladed spades, called *grafts*, and piled the clay in large heaps for rain and frost to weather it. In April they turned it over, tempered it with water, then kneaded it with bare feet. In the early twentieth century mechanical excavation by power shovels, and by 1930 draglines, progressively penetrated older underlying clays and enabled stockpiling. From the pit the clay is taken away by conveyor belt, tubs on a tramway, or by dumper truck.

The pugmill was probably invented by the Dutch in the seventeenth century. It is a vertical tub of wood or iron with a shaft from which projects a spiral of horizontal knives. A horse, harnessed to the end of a long beam joined to the shaft head, circles the mill. Clay is fed into the top, kneaded by the knives and extruded from the bottom. Children were often employed to

carry or barrow the clay to the moulding bench.

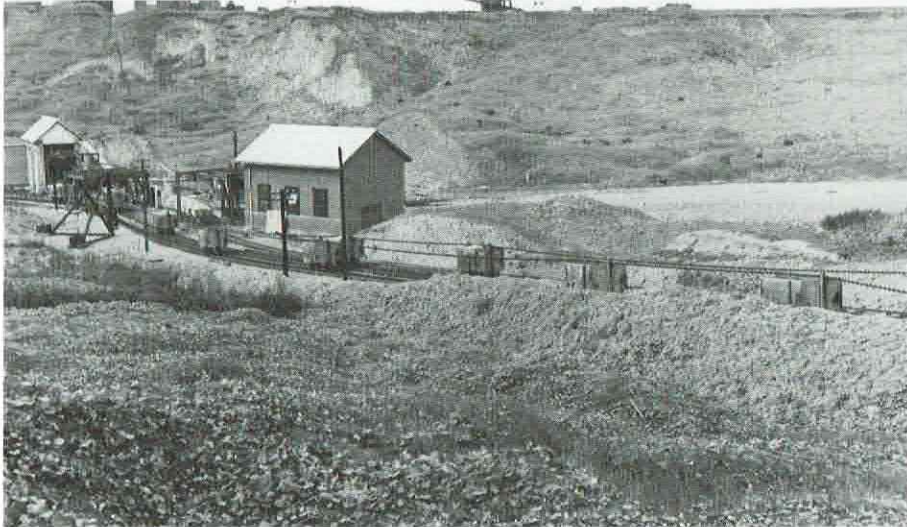
Even the Romans removed inclusions like grit and stones to produce a plastic, well tempered clay. Sand and other ingredients came to be added in the course of time. Rectangular box-feeders with compartments for each material and a belt at the base now feed the mixture in the correct proportions to the grinding mills. Small amounts of manganese dioxide, to turn red clays chocolate and buff clays grey, or barium carbonate, to reduce the efflorescence of soluble salts, are added.

In the pan mills two massive rollers crush the clay, forcing it through the perforated bottom of a circular pan, which may be either a *dry pan* or a *wet pan*, according to the clay and moulding process. Dry pans are for hard clays and semi-dry pressing, and wet pans are for hand-moulding and soft-mud processes. Dry-ground clays are sifted on a *piano-wire*

screen which catches oversize material for further grinding. Wet-ground clays pass through a mixer, an open trough with two parallel rotating shafts bearing blades to

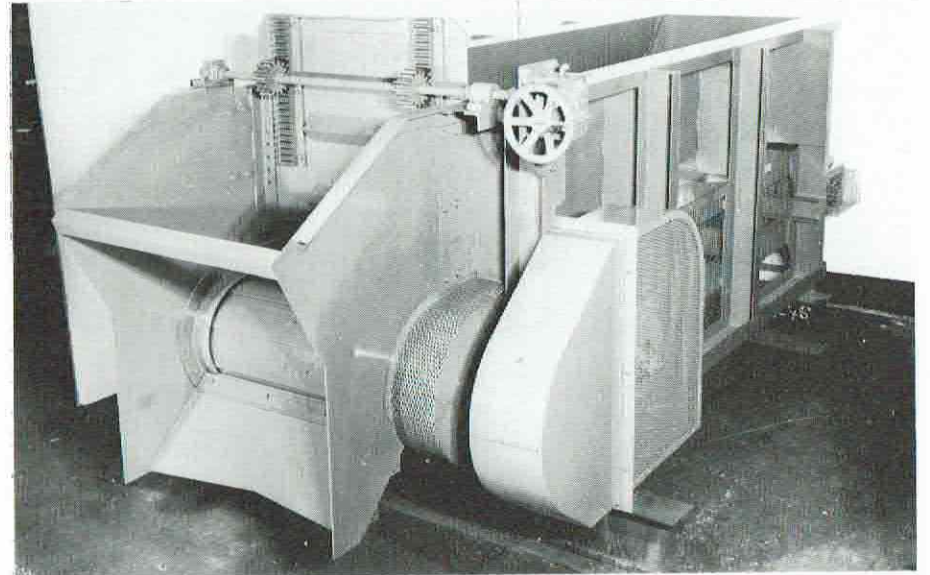
combine the ingredients, perhaps with more water.

The clays are now worked ready for moulding.



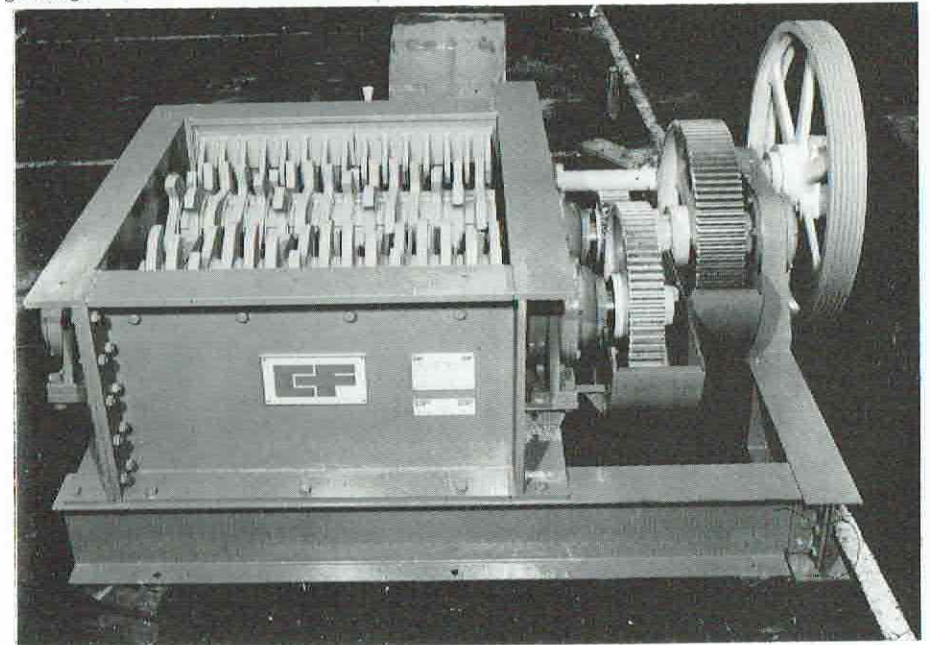
ABOVE: Haulage to the works. The tubs were pushed by hand along the quarry tramways to the foot of the incline leading to the works and then were attached to an endless chain, which hauled them up and returned the empty tubs. Each tub held about 2 tons.

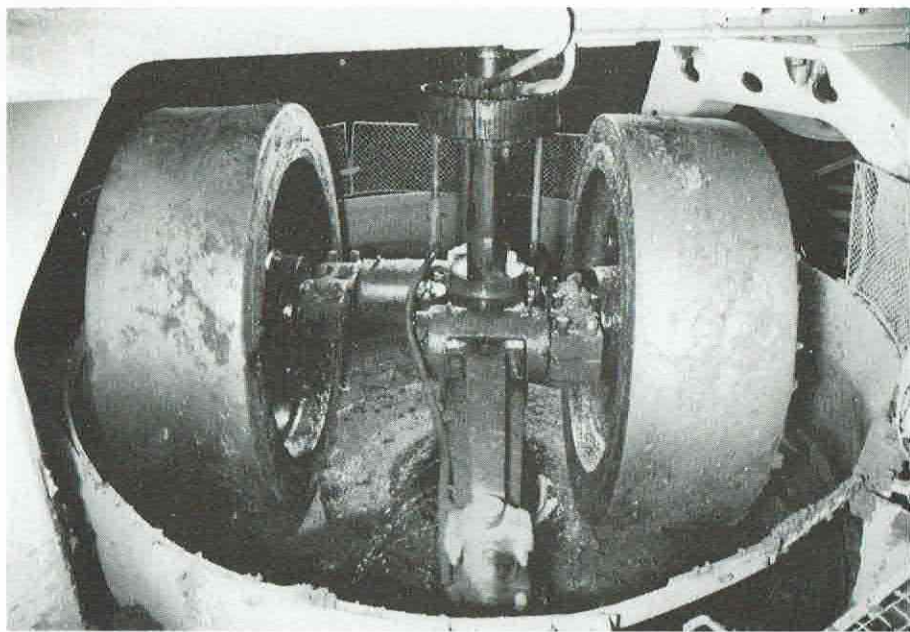
BELOW: Loading weathered clay into a dumper truck from a stockpile.



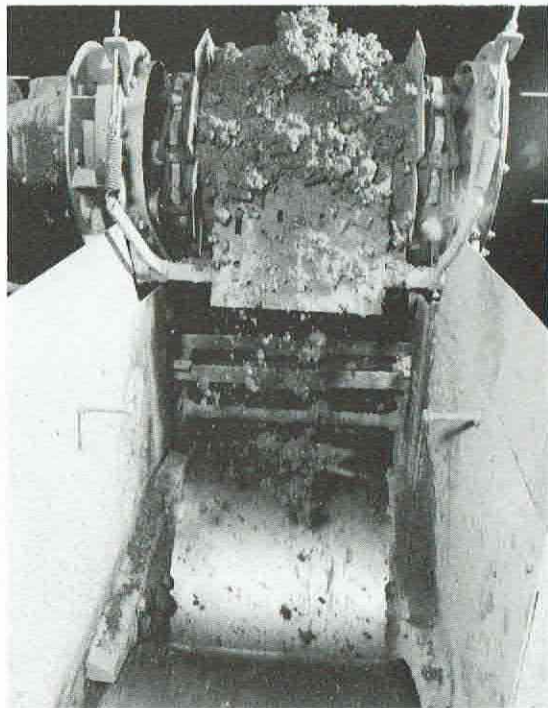
ABOVE: A box-feeder, which receives the raw materials and delivers them at a controlled rate. It has a moving steel slat bottom and an adjustable gate which regulates the depth of material leaving the feeder.

BELOW: A double-roll kibbler, used for breaking up hard clays into small lumps suitable for further grinding.

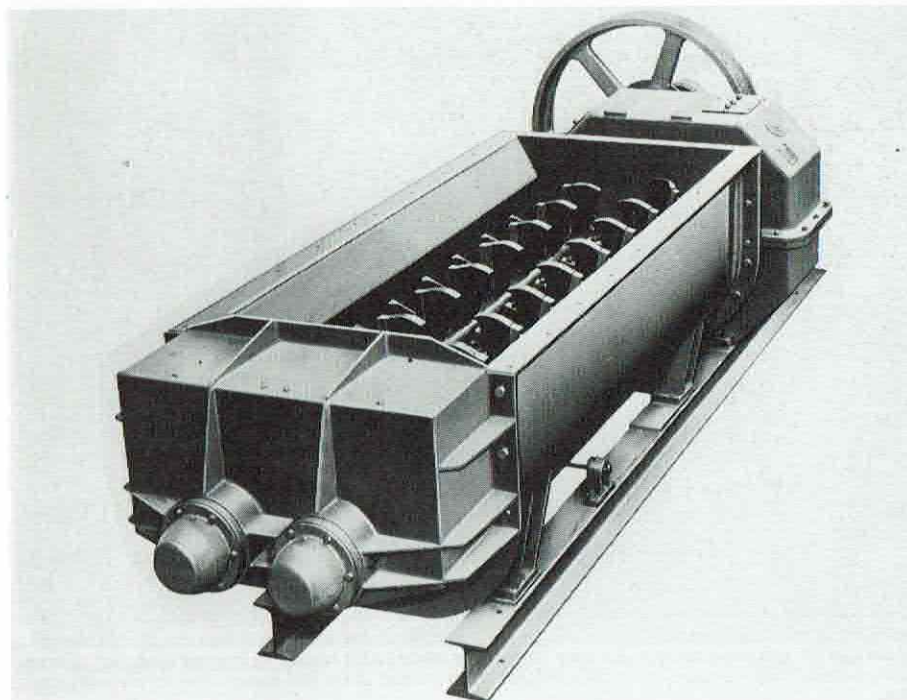




ABOVE: A wet-pan mill for soft moist clays. The rollers revolve on a stationary base with slotted grids, crushing and kneading the clay and forcing it through the grids. Water is added by a spray.

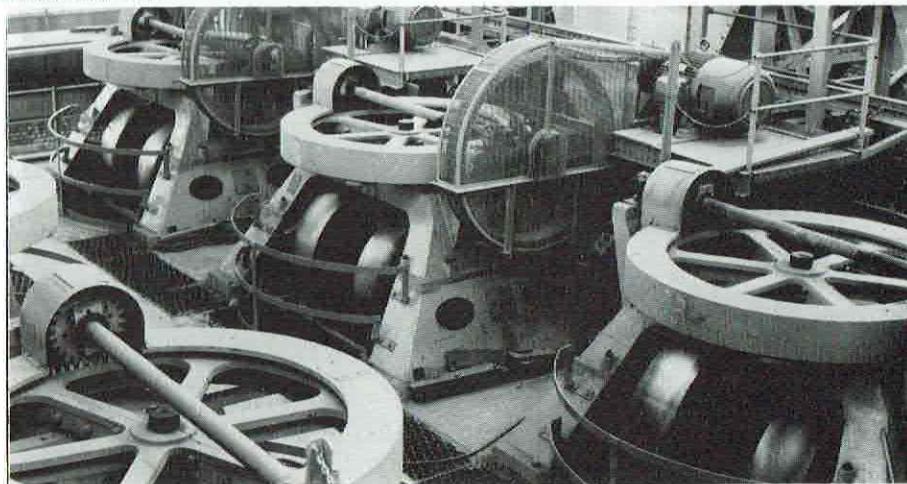


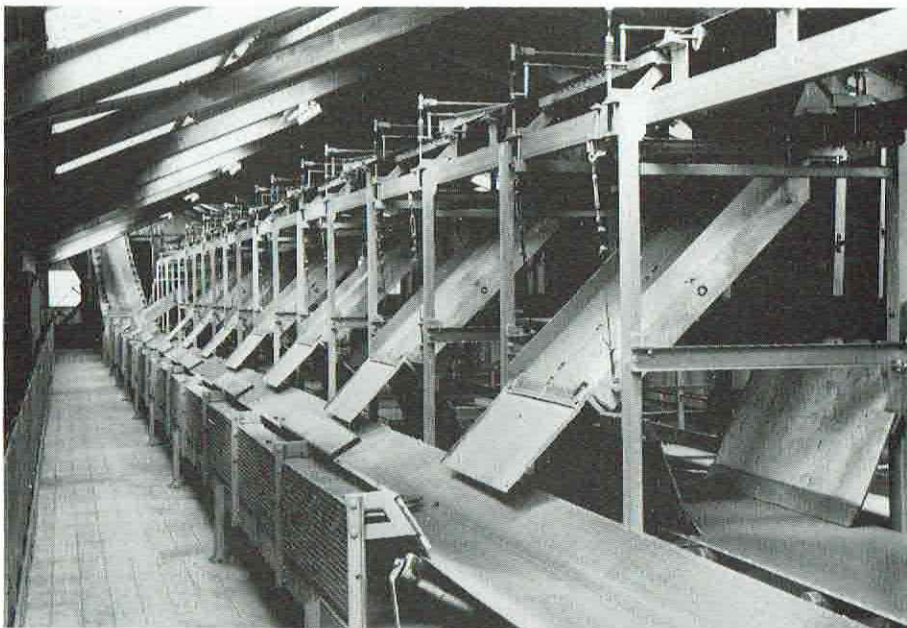
RIGHT: Differential-speed rolls for the fine grinding of clay, crushing any small stones and harmful inclusions such as lime. There is a slight gap between the rolls, which rotate towards each other at different speeds, giving a tearing action. Horse-driven crushing rolls were first used by Nathan Bradshaw of Mapperley, Nottingham, in 1820.



ABOVE: A double-shafted mixer, in which the clay and water are kneaded together by two rotating shafts fitted with knives. The clay enters at one end, is discharged at the other, and water is sprayed on it.

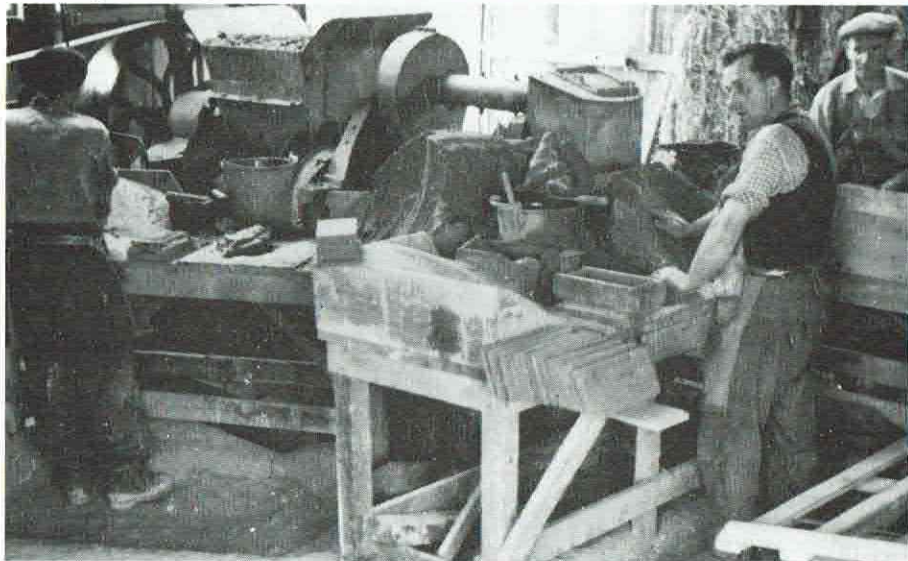
BELOW: Dry-pan grinding mills, Craven Fawcett 'Incla' type. As the pan rotates, the clay is crushed by the rollers and spread by centrifugal force over the sloping perforated sides, through which it falls. Oversized particles fall back under the rollers for further grinding. Clay is fed in from a hopper behind each mill.





ABOVE: Piano-wire screens. Ground clay from the mills is fed on to these screens, which consist of parallel wires spaced a certain distance apart and electrically heated to prevent clogging. Correct-sized material falls through on to the conveyor beneath and oversized material on to the conveyor in front.

BELOW: Hand-moulding at South Cove. The Lintott mill in the background supplies the three benches with clay pug by an Archimedean screw. The man in the centre has a supply of pallet boards on the 'page' to his left. Behind him is a hack barrow.



The sequence of hand-moulding. Taking clay from the heap on the bench, using a two-handed 'cuckle'.

MOULDING

The Romans chose a hard flat drying ground, sanded it and set wooden frames, into which they pressed the tempered clay. After the frame was removed, the bricks were left to dry until stiff enough to prop together in pairs — Roman bricks were too broad and thin to stand on edge in hacks.

In the late twelfth century two other methods were introduced — *pallet* moulding and *slop* moulding. For pallet moulding the moulder nails a *stock board* to his bench. From the late eighteenth century a raised block or *kick* was fixed to the stock to form the *frog* or recess in the bottom of each brick. The pallet moulder dusts his mould with sand and sets it on the stock. Sprinkling more sand on the bench, he rolls sufficient clay in it to form a rectangular *clot* or *warp*, smaller and deeper than the mould. This he throws hard into the mould so as to fill every corner. He cuts the excess clay from the top with a wire

bow and throws it aside for the next clot, then smooths the surface further with his *strike*, a stick moistened with water. He lifts the mould off the stock and turns the brick out on to a *pallet board* for his *bearer-off* to remove on a *hack barrow* to be set or *pitched* on the *hack* or drying platform to dry. This process produces sand-faced bricks. Moulders now usually do their own bearing off.

Until the twentieth century many bricks in the Midlands and the North of England were *slop*-moulded. Here, the moulder wets the mould instead of sanding it and places it directly on the bench without a stock. The moulded brick, being softer, is laid on a sanded *flat* to dry for a day before the moulder's boy sets it on the *hack*.

In the nineteenth century mechanised pallet moulding became the soft-mud process, producing stock bricks to imitate the hand-made product. Clay of similar



The sequence of hand-moulding. ABOVE: Forming the clot by rolling it in dry sand on the bench. BELOW: Throwing the clot into the mould. Standard-sized brick moulds are of hardwood lined with steel, though plastics are now being introduced. Moulds for specials are of wood.



The sequence of hand-moulding. ABOVE: Cutting off the excess clay with a wire bow. BELOW: The full mould is lifted off the stock board and the brick turned out on to a pallet.





The sequence of hand-moulding. Setting the brick on a stillage for drying. It is picked up between two pallet boards.

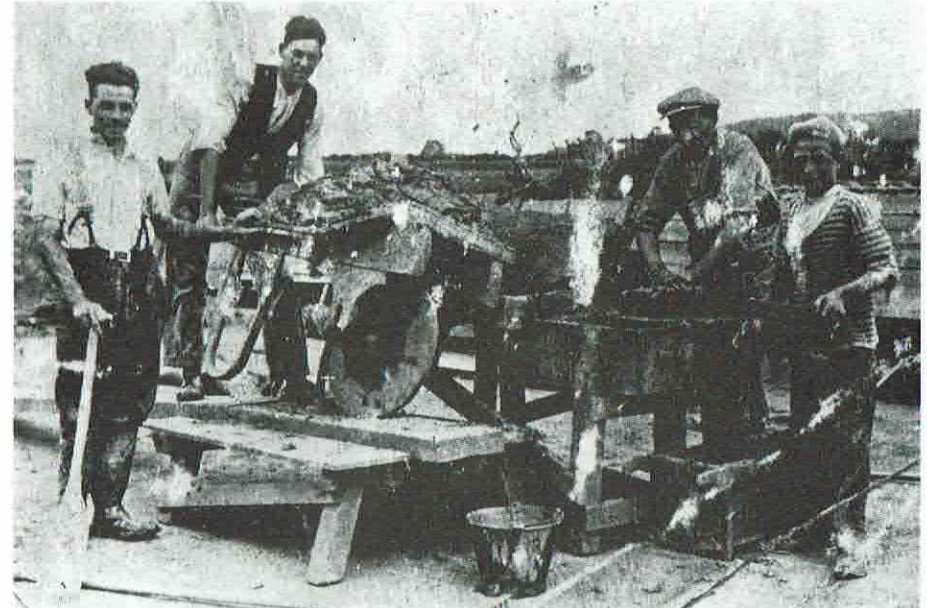
consistency is used but now a powerful pugmill forces it into sanded multiple moulds, forming up to twelve bricks at once. The same machine automatically inverts the mould to release the bricks on to a pallet and returns it for washing and re-sanding ready for refilling with clay.

Between 1820 and 1850 inventors patented 109 brickmaking machines and kilns. Some of these were displayed at the Great Exhibition of 1851. One such was a mixer-extruder, producing wirecut bricks. It used a clay stiffer than the hand-moulder's. The earliest wirecut machines were called *stupidis*. A box was filled with clay and its hinged lid clamped down. A piston inside, worked by a hand-turned rack and pinion, extruded the clay through a rectangular mouthpiece of similar section to the length and breadth of a brick. The box had to be refilled after each piston stroke. After 1860 extrusion was continuous. When a 3 foot (0.9 m) column of clay emerged the machine pushed it sideways against a frame of taut wires, slicing it into about ten bricks (numbers varied

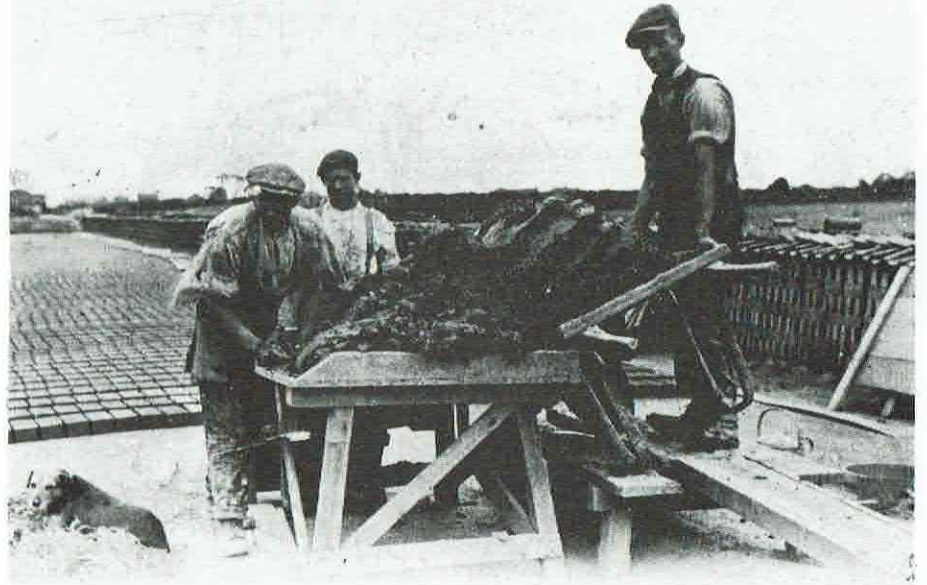
with machines), with spare at each end. When partly dry, the bricks required finishing in hand-operated presses.

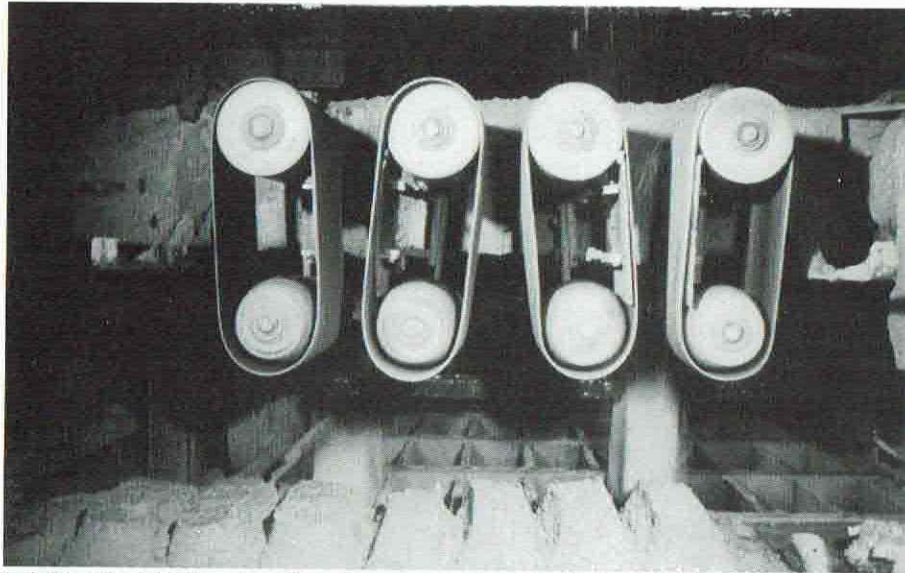
Around 1900 de-airing was introduced, and today most wirecut machines incorporate a vacuum chamber in which the clay is shredded before compression by the extrusion auger, yielding a denser, more plastic product. The clay column may be textured for facing bricks. Either wires remove thin slices from three sides to create *rustic* facings, or the sides are sandblasted. Most modern wirecuts are perforated, which makes them cheaper to dry and fire and lighter to handle.

The stiff-plastic process suits the shales and harder clays. Before processing, these are ground, screened and dampened. An initial pressing forms a rough rectangular clot, which is squeezed between two dies to form a smooth-sided brick with a frog on the upper surface and sometimes the lower surface also. The press ejects the finished article. Sandblasting textures facing bricks. Recently stiff-extrusion, forming wirecut bricks using stiff-plastic clay and a power-



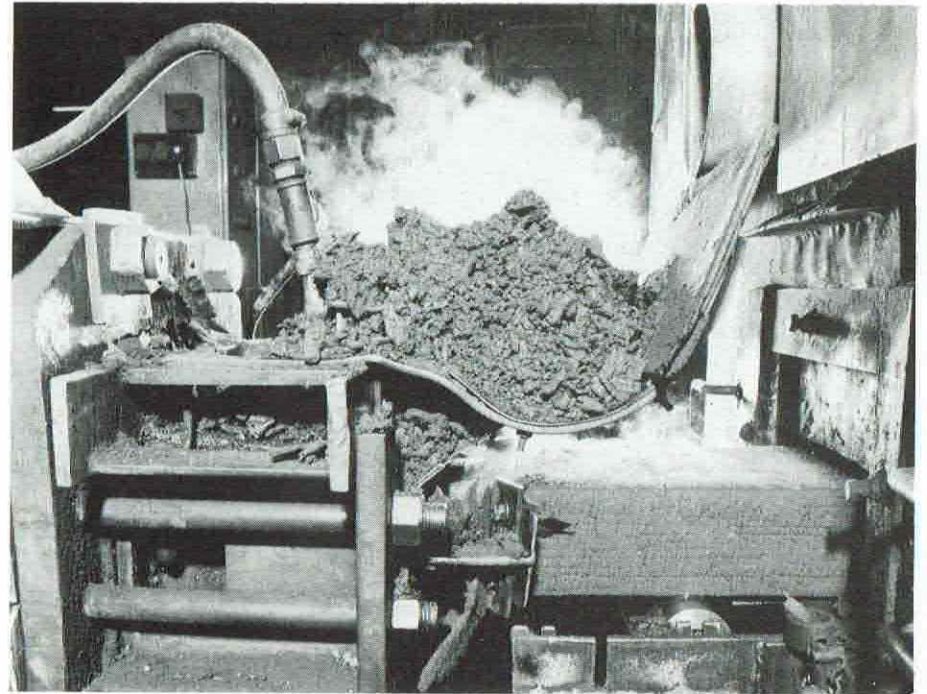
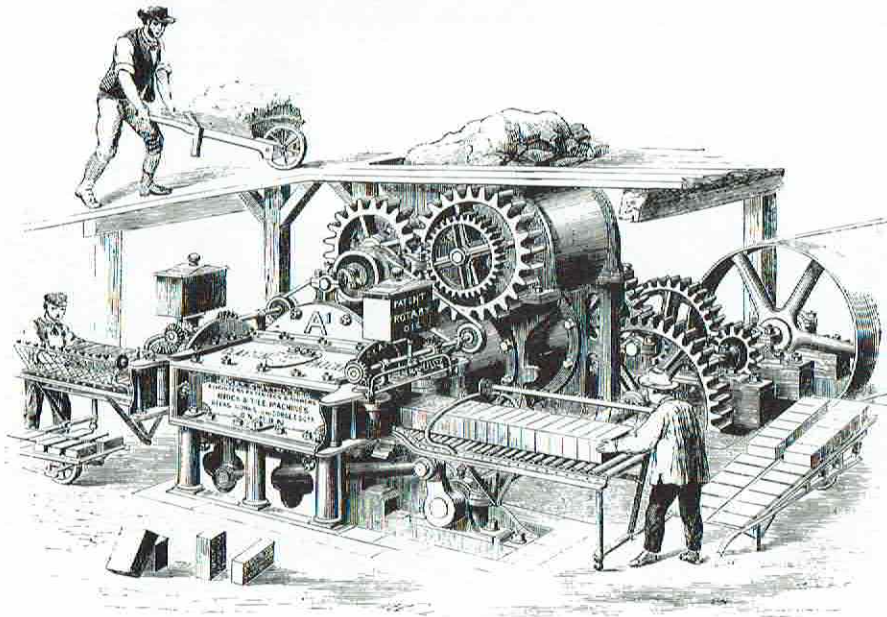
ABOVE: Slop moulding, Ferriby Sluice, Humberside, c 1920. The moulding bench is being restocked with clay from the barrow. The moulder is smoothing the top of a brick with wet hands and the boy has a filled mould ready to take to the 'flat'. A water box is built into the bench top in front of the moulder and another box on the ground catches the slurry from moulding. The rake in the foreground is for levelling the flat. The man on the left has a narrow-bladed 'graft' for digging clay.
BELOW: Slop moulding. The bricks drying on the flat before being set in the hacks.





ABOVE: The 'Wealdmade' soft-mud process developed by Redland Bricks Ltd to imitate hand moulding. The clots drop between the pairs of rotating belts into the moulds. The excess clay is then struck off and the bricks are turned out.

BELOW: Clayton's brickmaking machine. 1863. Clay fed in at the top falls between a pair of crushing rolls into the extruder. Two clay columns are extruded sideways, cut by wires on a hand-operated frame and the bricks placed on the hack barrows. The two little tanks over the mouthpieces hold water for lubricating the clay column.



ABOVE: Producing a 'rustic' texture on the clay column.

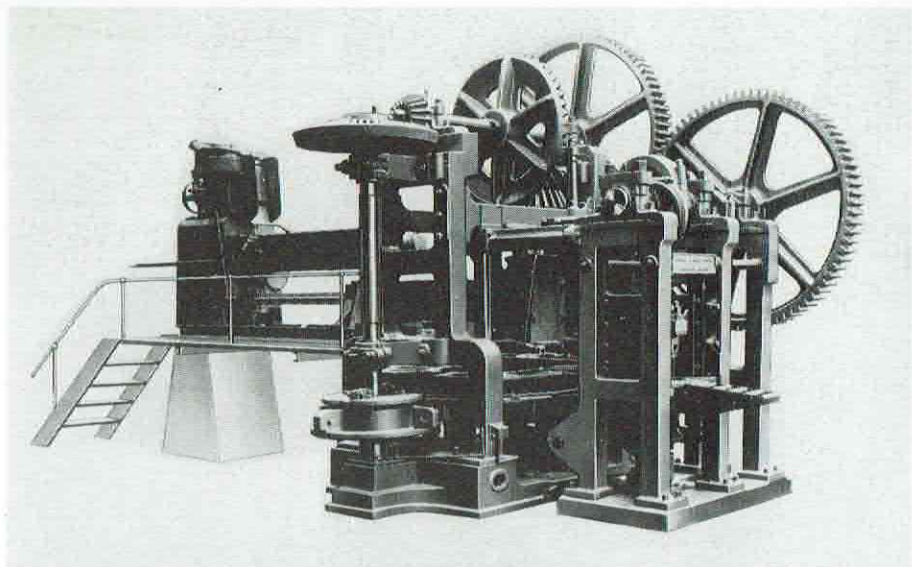
RIGHT: An early set of 'rusticating' rollers.



ful extruder, has superseded this process.

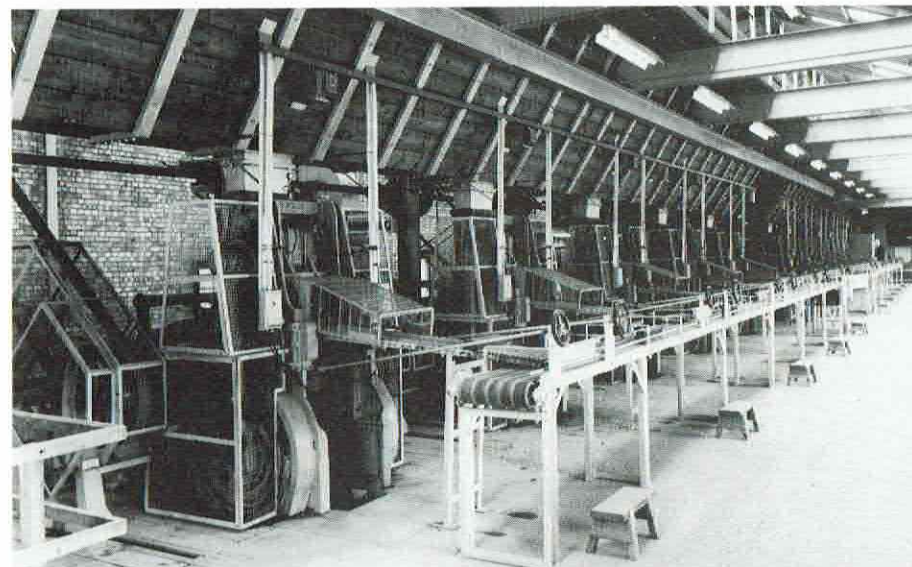
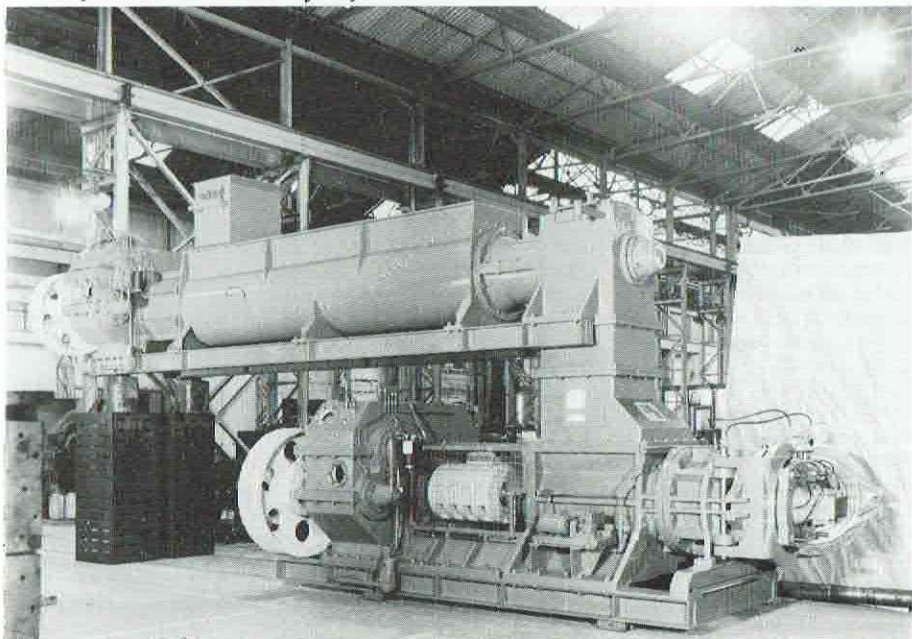
Semi-dry pressed bricks are made of hard shale ground to a coarse powder and screened, with little, if any, water being added. The damp but loose powder passes to hoppers which feed measured amounts to the powerful presses, where each brick is pressed two to four times, hence the London Brick Company's trade name 'Phorpres', discontinued in 1974. After the first pressure the plunger withdraws to release trapped air; further pressings consolidate the brick, which finishes smooth. Further treatment by sandblasting or scratching can texture it for facings. All Flettons are formed thus, and they pass to the kilns without preliminary drying.

In all the processes moulds are sized to allow for shrinkage in drying and firing.



ABOVE: Bradley and Craven Number 1 stiff-plastic brickmaking machine. Developed from John Craven's original patented in 1859, it comprises a mixer, a vertical pugmill, a rotating mould table and a press.

BELOW: Craven Fawcett Steele 90 BD HD extruder for stiff-plastic extrusion, incorporating a mixer and vacuum chamber. It weighs nearly 32 tons, requires a power input of 720 horsepower (537 kW) and can process 60 to 80 tons of clay an hour.



Whittaker semi-dry presses form the damp powdered clay from a hopper above into bricks, two at a time, and push them down on to the conveyor belt running past.

DRYING

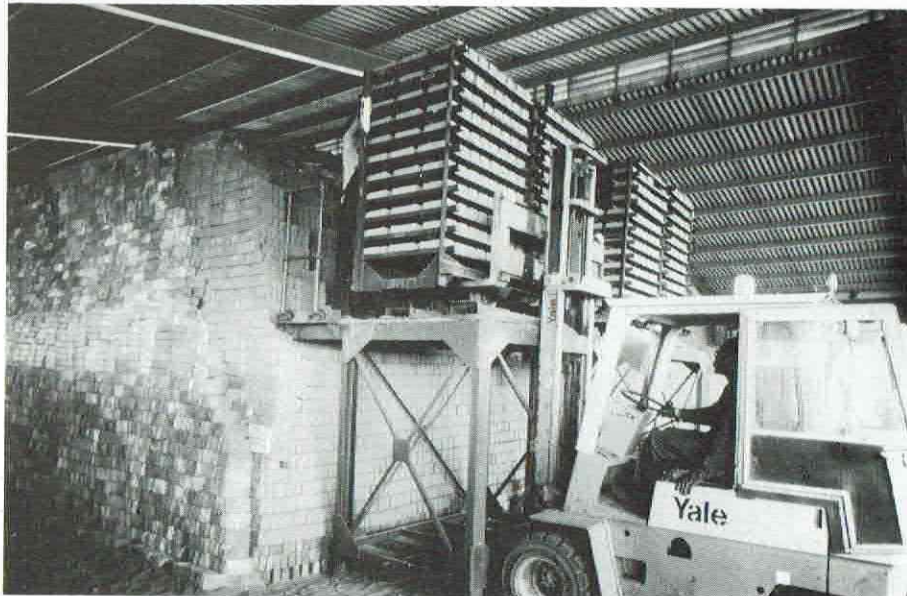
Bricks must be thoroughly dry before firing unless they are sufficiently hard and dry after forming and the firing allows for removal of residual moisture.

The account of traditional moulding left the bricks on the hack barrow in the hands of the bearer-off. He removes them between two pallet boards and sets them on edge, about $\frac{1}{2}$ inch (12 mm) apart, in two rows up to eight courses high on the hack, a slightly raised timber platform protected either by movable wooden *hack caps* or permanent open-sided sheds, with *loo boards* at the sides to repel driving rain. He sets one course at a time to allow the bricks to stiffen before he adds the next. When hardened, the bricks were *skintled* — set diagonally and further apart to speed up the drying, which took three to six weeks according to the weather.

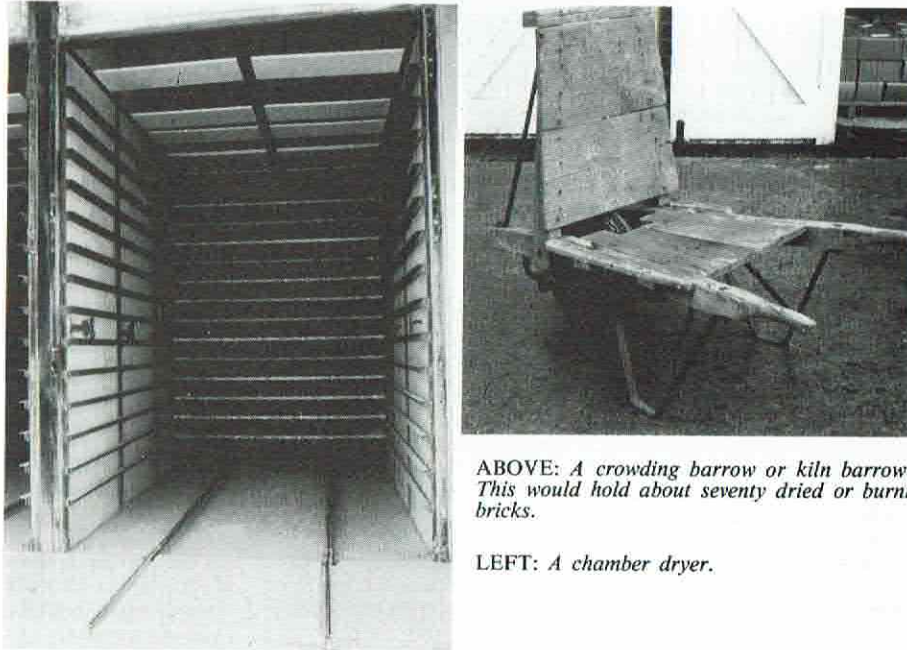
Early in the nineteenth century, particularly in the Midlands and the North of England, hot-floor dryers were introduced, heated by underfloor flues piping hot air from a furnace or steam from the works engine. Bricks were set on end in a single layer on these hot floors.

Of chamber dryers the Keller is the commonest. Corridors 50 to 75 feet (15.24 to 22.86 m) long, 5 feet (1.5 m) wide and 9 feet (2.74 m) high are built in groups and heated from below by steam pipes or, more often nowadays, by air heaters or waste heat from the kilns. The bricks are set on edge in rows on pallets resting on ledges in the walls. Drying begins by circulating cool humid air to avoid cracking the bricks, ending with hot dry air. Temperature and circulation are adjusted to control humidity. A finger-car, a kind of fork-lift truck, can lift a whole row of pallets off the ledges simultaneously when loading and unloading the dryer.

In tunnel dryers, setters stack the bricks on racks on trucks which travel slowly through a tunnel heated as before but with fan circulation. A counter-flow system admits hot air at the exit, which is extracted at the entrance, so the bricks meet a cooler, more humid atmosphere at the start and have optimum drying conditions. These tunnels are 80 to 120 feet (24.38 to 36.38 m) long, 4 feet (1.2 m) wide and 5 feet (1.5 m) high.

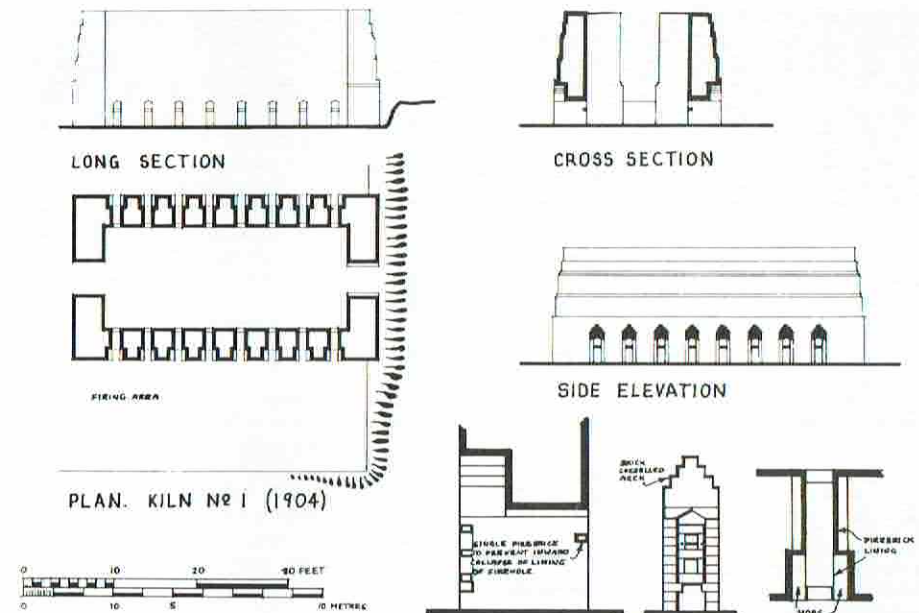


ABOVE: Setting bricks in a gas-fired clamp at Sittingbourne, Kent. The bottom three courses are of underburnt bricks from a previous firing, and the casing is of waste bricks. Gas burners are applied to the flues visible at the base of the casing. The works was established in 1845 by Smeed and Dean and in the 1880s was the largest in Britain, producing eight million London stocks annually.



ABOVE: A crowding barrow or kiln barrow. This would hold about seventy dried or burnt bricks.

LEFT: A chamber dryer.



The scotch kiln, used in many small brickyards throughout Britain until the Second World War, when many closed down. This is a typical example, from Sandleheath, Hampshire, holding forty thousand bricks and consuming sixteen tons of coal for each firing. Few had grates in the fireholes or vaulted tops.

FIRING

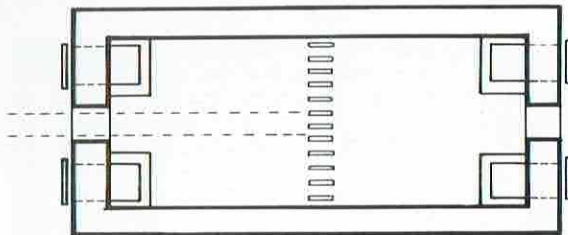
To change dried mud into stone the bricks must be burnt at a bright red heat (950-1150°C, 1742-2102°F). The clamp probably preceded the permanent kiln, but one cannot be certain as the word 'clamp' could be applied to either structure in early accounts. Setters skilfully stacked the bricks, spaced apart to allow the fire gases to circulate, and formed fire channels in the base, finally covering the whole with turf and old bricks. The burner then lit and tended the fires.

After the Great Fire of London (1666), when byelaws for rebuilding stipulated that brick must be used, close clamps were used for London stocks, in which fuel was mixed with the clay and the bricks were set close together. *Town ash* from refuse heaps outside the city was sifted, the finer ash being added to the clay in the washbacks, the coarser spread in a thick layer at the bottom of the clamp and ignited by faggots and coal in a transverse flue or *live hole*. Once the bottom courses were red-hot the fuel in the bricks themselves started to burn

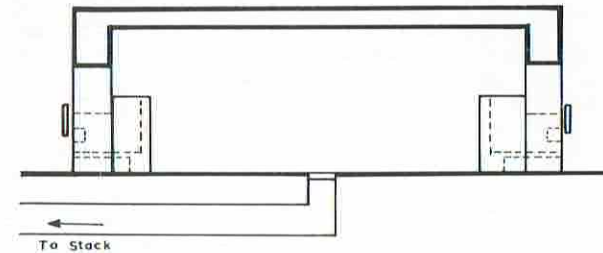
and the heat permeated the whole clamp of up to a million bricks, taking two to six weeks. Those nearest the outside were lightly burned and might be refired; the best came from the centre.

Today, ninety-five per cent are saleable after grading. London stocks, formerly in ten grades, now usually come in three. In south-east England today the mixing of clay with coke breeze, anthracite dust or town ash, which contains much half-burnt coal, is universal for both clamp-fired and kiln-fired bricks. In 1973 Rudgwick Brickworks in Sussex pioneered the use of liquefied petroleum gas (LPG) for ignition, using small fire channels and dispensing with the layer of fuel.

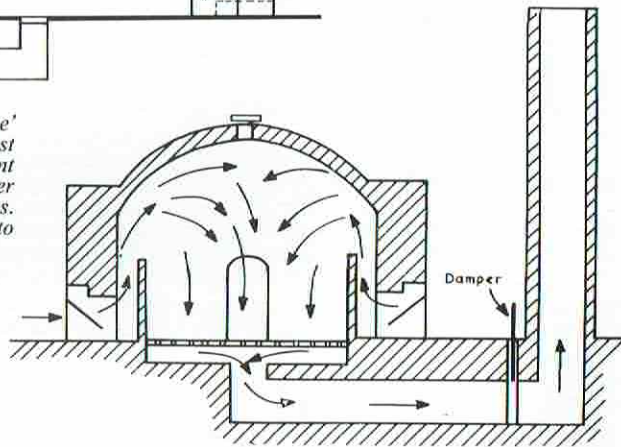
The Romans burnt their bricks in small rectangular kilns similar to the Suffolk kiln described later, but usually with only one fire tunnel. These have been excavated at several sites, notably at Holt, Clwyd. Any Saxon brick clamps or kilns have yet to be found. Only where brick was constantly required, as at Portsmouth, Hampshire, or



LEFT: Double-ended Newcastle kiln, once found in large numbers in north-east England, and occasionally elsewhere. A third firehole may be formed at each end when the wickets are built up.



RIGHT: Circular 'beehive' downdraught kiln, the most widely used type of intermittent kiln. Often found in smaller works producing facing bricks. Capacity thirteen thousand to forty thousand bricks.



Carisbrooke, Isle of Wight, and later Hull, did medieval kilns occur. The only significant improvement of kilns came in the mid seventeenth century, with coal firing.

At about this time scotch kilns evolved from clamps. These are open-topped chambers 11 feet (3.36 m) wide by 12 feet (3.65 m) high. At each end is a doorway or wicket and on each side, depending on the kiln's length, six to ten fireholes at 3 feet 6 inch (1.06 m) centres. Fire channels 9 inches (230 mm) wide by 3 feet (0.9 m) high and corbelled over are formed between opposite fireholes. A solid wall of bricks, the *old man*, divides the kiln lengthwise to prevent crossdraughts. After filling to the top, the setting is covered with loose burnt bricks. The burners open and close the gaps between these to control the

draught. Firing takes from three to five days. Fourteen oil-fired scotch kilns are still in use in yards at Aldeburgh, Suffolk, and near Chesham, Buckinghamshire. The newest dates from 1980. They survive despite inefficiency and fuel costs because they can produce beautifully coloured bricks.

The Suffolk kiln developed directly from Roman and medieval models. Many disused examples remain in East Anglia, often built into sloping ground. The bricks were set on the level floor of the open-topped firing chamber and the top was sealed as before with old bricks. Flames reached the chamber through slots in the arches of the two or three fire tunnels below the floor. When wood was used for fuel it went through grates. These kilns were substantial

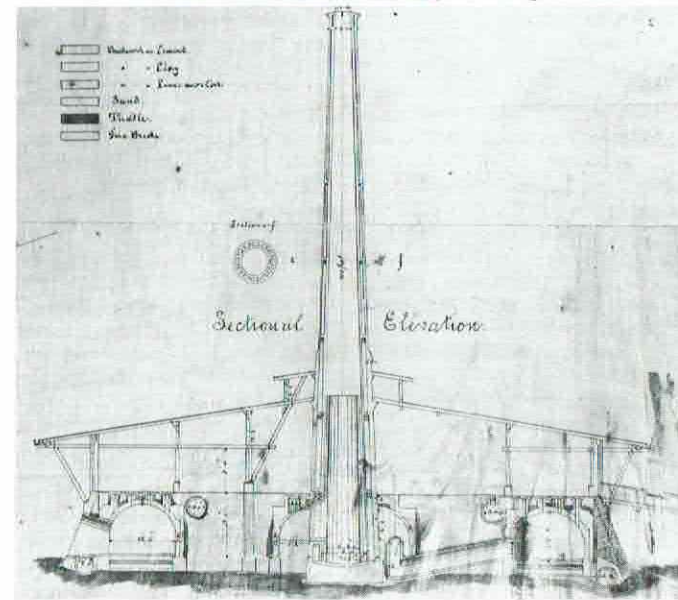
buildings with covered stoking areas and a coal cellar on one side and often a messroom complete with fireplace on the other. Two burners, working in shifts, remained at the kiln for the whole three-day firing period. Elsewhere, burners were lucky to have a roof over their heads at all. The last wood-fired Suffolk kiln, at Ashburnham Manor, Sussex, closed down in November 1968; a coal-fired kiln at South Cove, near Lowestoft, Suffolk, is temporarily out of use. Blackout regulations during the Second World War forced most open-topped kilns to close down, and afterwards many were never used again.

On Tyneside both building bricks and firebricks were burnt in horizontal-draught Newcastle kilns, because they attain high temperatures. The vaulted chamber is 11 feet (3.36 m) wide, 10 feet (3.05 m) high, and 16 to 30 feet (4.88 to 9.14 m) long. The smallest have two fireholes and a wicket at one end and a chimney at the other. The larger are double-ended, with fireholes and wickets at each end and a central flue. They may be built in groups of three or more.

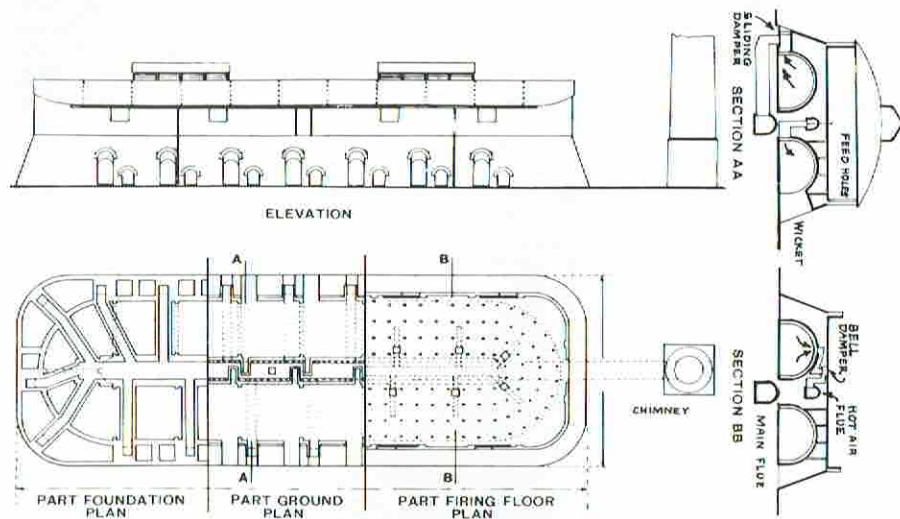
Downdraught kilns are circular or rectangular in plan, with fireholes and wickets in the walls. Within the chamber the fire

gases pass up to the roof through *bags*, flues built against the walls, then down through the setting and out through the perforated floor and underground flues regulated by dampers, to a detached chimney. These kilns are easily controlled for oxidation or reduction – excess or deficiency of oxygen in the kiln atmosphere – to obtain particular colours. Capacities vary from thirteen thousand to one hundred thousand bricks; the largest were used for blue bricks. They are often found in small works, producing hand-made bricks. A few are still coal-fired by hand or with automatic stokers, but most have been converted to oil or LPG. Builders of 'beehive' kiln domes judge the curve by eye and rely solely on the adherence of the fireclay mortar to bond the firebricks.

Although James Gibbs and Thomas Ainslie patented multi-chamber kilns in 1841 and 1843 respectively, the best known continuous kiln is named after Friedrich Hoffmann, who designed it in 1856, patenting it in 1858. The annular gallery in which the bricks are set is divided into twelve or more chambers, each with a wicket and a branch flue with a damper, leading to a main flue and chimney. Paper dampers stuck to the bricks maintain an airtight bulkhead between chambers until



Section through a circular Hoffmann kiln, from a drawing produced by Hoffmann's office in Berlin for the Lilleshall Company, Donnington Wood, Shropshire, in October 1875. This kiln was provided with flues for hot air and the removal of steam in the early stages of firing.



A typical rectangular Hoffmann kiln, from the period 1890 to 1960.

the hot gases burn them away. Each chamber is set, burnt, cooled and emptied in sequence and the waste heat used to preheat the freshly set bricks. The firing zone is advanced round the kiln by opening the flue dampers ahead of it. Fuel, originally slack coal, is fed in through small feedholes in the chamber arch and burns in the spaces between the bricks. The first kilns were circular in plan, but in 1870 Hoffmann designed a rectangular version. Since 1858 much has changed, particularly in the flue system to give the best heat distribution. Fire gases will discolour the bricks, so in 1870 Hoffmann introduced hot-air flues to carry clean air direct from the cooling chambers to the preheating chambers, bypassing the firing zone.

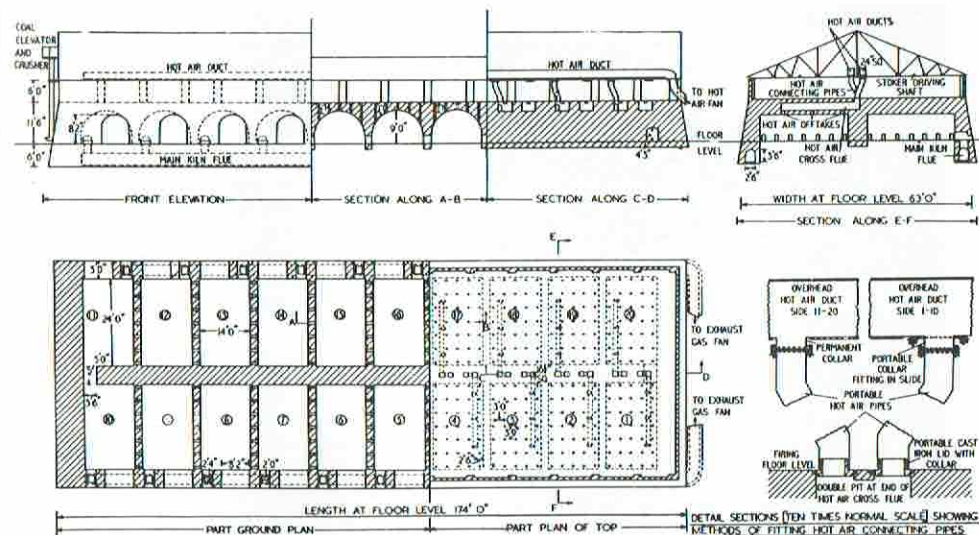
In 1862 John Craven, inventor of the stiff-plastic process, ordered the first English 'Hoffmann' for his Roundwood brickworks, sited between Wakefield and Dewsbury, designed by Humphrey Chamberlain, the British patentee. The maximum span of the chamber arch was about 18 feet (5.5 m). Around 1890, in order to increase capacity without increasing the *effective length* (the distance the fire travels in one circuit of the kiln), the transverse-arch kiln was designed, in which the arches could be of any length because they lie across the flow of fire. In 1904

Dean and Hethrington, of Accrington, Lancashire, patented the Staffordshire kiln to burn blue bricks. This incorporated transverse arches, and flues and dampers to control the fire closely; and for the next fifty years it dominated the design of many large kilns.

In order to obtain higher temperatures than could the Hoffmann, the Dubois d'Enghien brothers of Hennuyères, Belgium, patented the Belgian kiln. Their original four kilns, built between 1891 and 1909, still survive at their works, although somewhat altered inside. British examples were built for facings and firebricks. They used a system of grates set in the chamber floor at 10 foot (3.05 m) intervals, stoked through firedoors formed in the wickets.

The French Royal Porcelain Factory had the first tunnel kiln in 1751, but few were built in Britain for firing bricks until the 1970s. They were expensive to build and there were various technical problems, which outweighed the advantages of fuel saving and better working conditions. Early models used coal. The Bricesco-Harrop type had mechanically stoked furnaces at intervals in the walls of the firing zone; the Monnier top-fired type was fed with slack coal from overhead hoppers. Now all burn oil or gas.

The earliest tunnel kilns were about 6



ABOVE: A Staffordshire transverse-arch type kiln. The chambers are linked by 'trace-holes' through the walls, which could be closed by dampers.

BELOW: Feeding a continuous kiln for Fletton bricks with coal. The small covers are the feedhole caps; the large covers give access to the chamber offtake and inlet bell-dampers in the hot air flues.

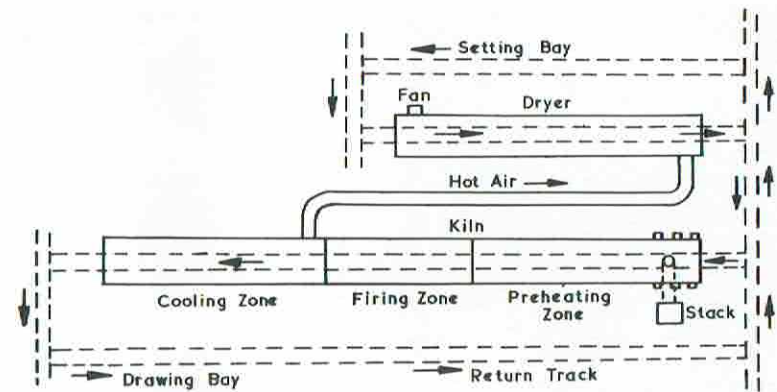




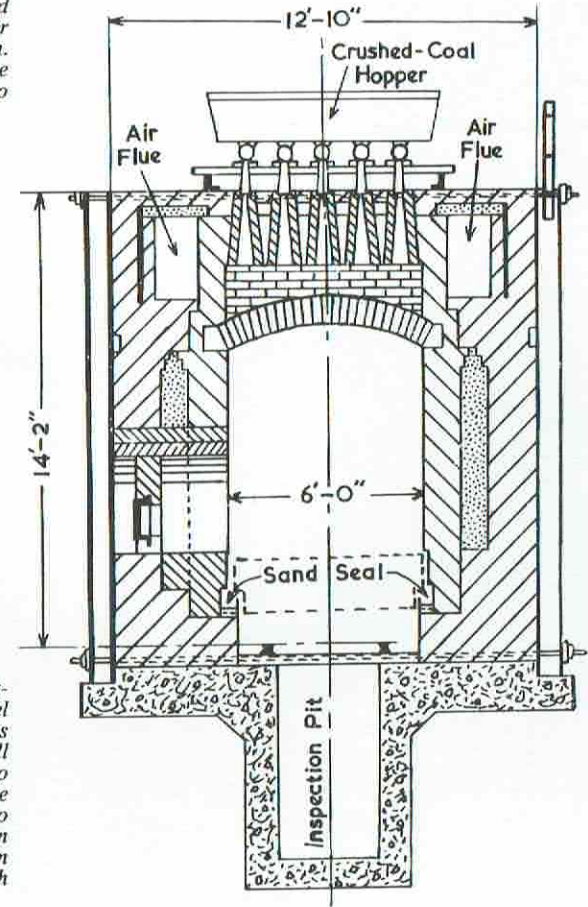
feet (1.8 m) square in section, but modern ones are double this width and 300 to 400 feet (90 to 120 m) long. Cars loaded with about a thousand bricks pass slowly through the preheating, firing and cooling zones. The car decks are insulated with firebrick and a heat-tight seal is formed with sand between them and the tunnel walls, protecting the bogies and rails underneath. As with drying tunnels, a counter-flow system draws air from the exit through the fire zone to preheat the bricks as they enter.

LEFT: Drawing fired bricks by hand in a Staffordshire kiln. This was hot and dusty work, with the coal ash and temperatures well over 100°F (38°C) in a newly opened chamber.

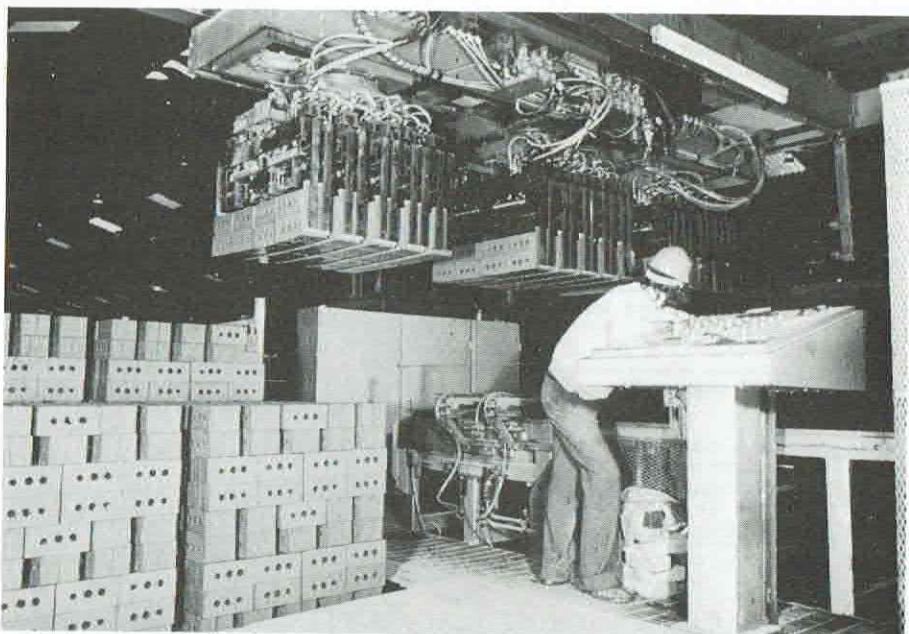
BELOW: Setting Fletton bricks in a kiln chamber. The fork-lift has tines with inflatable pads which grip the bottom course of bricks in each pack. Note the feedholes and hot-air off-takes in the arch.



ABOVE: Layout of tunnel kiln and dryer. The dryer uses clean hot air from the cooling zone of the kiln. Waste gases from the firing zone preheat the bricks before passing to the stack.

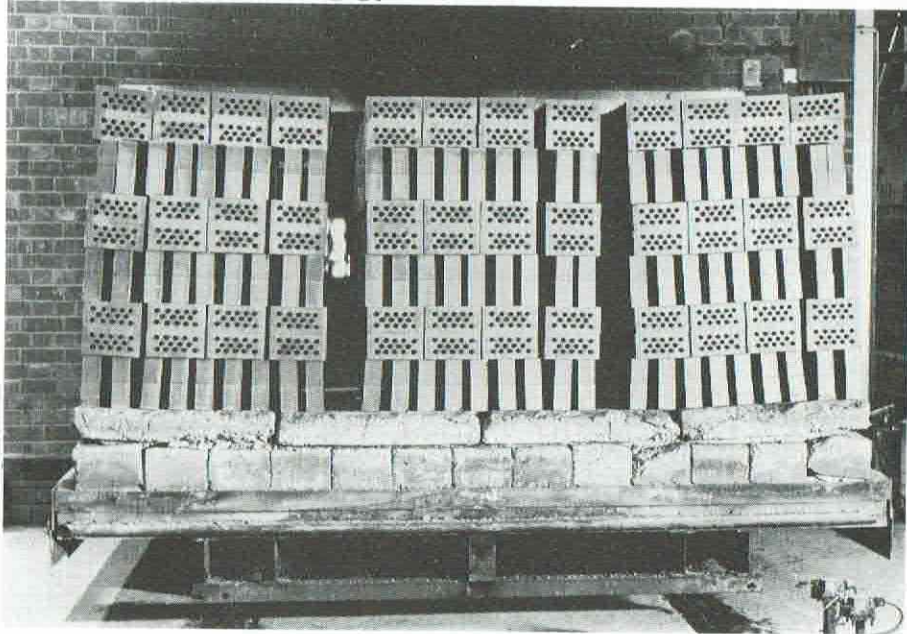


RIGHT: Section through a Monnier kiln, an early type of tunnel kiln, top-fired with coal. Feeders operated by rods from a small electric motor allowed the coal to drop intermittently from the hoppers through the twelve to fifteen rows of feedholes. The kiln was 300 feet long (90 m) on average, and bricks passed through in two or three days.



ABOVE: Automatic setting machine. In many modern works the bricks are set on the tunnel kiln cars by machines like this. Hydraulically operated grabs pick them up and turn them to give the chequer setting pattern.

BELOW: Car of fired bricks emerging from a tunnel kiln.



Pressing calcium silicate bricks, three at a time, in a rotary-table type press.

CALCIUM SILICATE BRICKS

In the late nineteenth century German experiments in making artificial stone resulted in a sand-lime brick process, patented in 1881. Production began there in 1894 but did not reach England until ten years later.

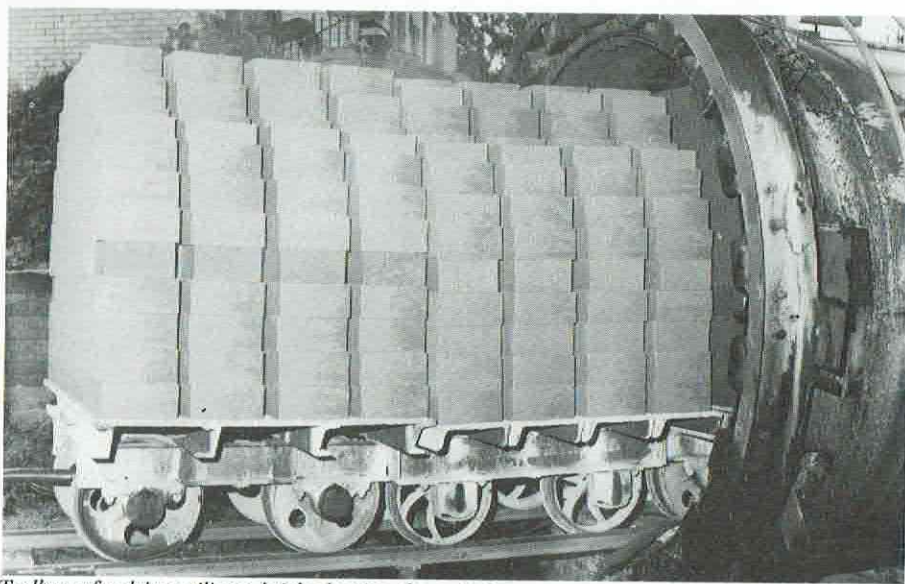
The ingredients are silica sand, water and lime, which may be purchased already slaked or as quicklime to be slaked after mixing with the other materials. Slaking takes forty minutes in a rotary slaking drum or twenty-four hours by storage in silos, following batch mixing. Metallic oxide pigments may be added to yield pinks, greys, yellows and browns. The whole is then thoroughly mixed in a rod mill, a rotating cylinder with loose steel rods, before being fed into powerful presses. These form up to eight bricks at once under

pressures of up to 200 tons. Two different-coloured mixes fed into the same mould produce multicoloured bricks. If the faces are brushed after pressing, fine flint gravel in the mix creates texture. Steel trolleys carry a thousand bricks each to the autoclaves for curing by saturated steam at 120 to 250 pounds per square inch (8.27 to 17.24 bar). The curing lasts for four to twelve hours, depending on the strength and quality required. The pressure takes an hour or two to build up and release. At the end of the cycle the autoclave door is unbolted and the train of eighteen trolleys winched out. A weak hydrochloric acid dip removes surface scum; otherwise the bricks are ready for despatch.

TRANSPORT

No artefact becomes a product until it can be used, so no account of brickmaking can overlook transport. Earlier brickworks were small and built to meet local demand. Railways and canals were used for long-distance transport but horses and carts

delivered loads of 350 bricks to the site. These days bricks are strapped in packs of four hundred to five hundred and delivered on special lorries incorporating handling equipment. Fork-lift trucks are found in all but the smallest works.



Trolleys of calcium silicate bricks leaving the autoclave.

THE BRICK ITSELF

The Romans shaped bricks to standard sizes. Some were 2 feet (0.6 m) square, but the commonest were the *lydium*, 18 by 12 by 1½ inches (457 by 305 by 38 mm) for walling and the *laterculus* 8 by 8 by 1½ inches (203 by 203 by 38 mm) for hypocaust pillars. Romans used brick less for whole structures than to bond rubble walling and to resist heat. Underfired bricks were ground up for use in mortar. Quite often the bricks are fragmentary, suggesting that cracking in firing was a serious problem.

Early medieval 'great bricks' were also large: 13 by 6 by 2 inches (330 by 152 by 51 mm). Later, British and foreign influences and different usages occasioned a variety of sizes from 8½ by 4 by 2 inches (216 by 102 by 51 mm), found dating from about 1268 at Little Wenham Hall, Suffolk, to those produced from 1303 at the town brickyards of Kingston-upon-Hull: 10 by 5 by 2 inches (254 by 127 by 51 mm). Increasing domestic use during the mid fifteenth century encouraged makers to mould or carve bricks to emulate ashlar. Moulds for bricks for Tudor chimneys had removable sides and vitrified headers were used for Tudor diaper patterning. By the

late fifteenth century a brick 9½ by 4½ by 2 inches (242 by 115 by 51 mm) became common. A charter of 1571 stipulated 9 by 4½ by 2½ inches (230 by 115 by 57 mm).

A wider variety of brickearths and accidents in firing created architectural opportunities. Late medieval kilns produced only a small proportion of the favoured rich red even colour for facings. In the wood-fired kilns of southern England fly-ash reacted at high temperatures with the local clay to produce silver-grey headers. There were soft bricks suitable only for internal work and very hard discoloured and distorted ones from the kiln bottom.

By the eighteenth century sizes had altered and methods had improved. In 1769 Parliament legislated for an 8¼ by 4 by 2½ inch (210 by 102 by 63 mm) brick. In 1784, to help finance the war with the American colonies, it imposed a duty of 2s 6d per thousand. It paid to make bricks bigger. 'Wilkes' Gobs' from Measham, Leicestershire, measuring 9¼ by 4½ by 4½ inches (235 by 110 by 110 mm) are a well known example of 'tax bricks'. However, in 1803 the government charged double duty on bricks exceeding 150 cubic inches (2,458 cc) when

moulded. Inspectors counted them during drying and allowed ten per cent wastage in firing. The tax was repealed in 1850.

The Victorians preferred a technically perfect brick, smooth, square and of even colour: such bricks gave contemporary towns their character. By 1840 stucco was deemed dishonest. Facing bricks returned to fashion, while Ruskin's *The Stones of Venice* (1852) advocated moulded and polychrome brickwork. For pale bricks, yards selected white-burning clays or added chalk. The railways carried different coloured bricks all over Britain. Later in the nineteenth century, with the 'Queen Anne' revival, plain reds returned; nor did the demand for hand-made bricks, from those able to afford them, ever die completely.

Bricks remained competitive for canal and railway engineering. These requirements exhausted the existing yards and were supplied by temporary works on site, as between 1822 and 1827 at Harecastle, Staffordshire, where they burnt

seven million blue bricks for the first major work to use them – the new canal tunnel.

At the close of the nineteenth century Lutyens and other architects revived 'traditional' vernacular and Renaissance styles. They wanted facsimile Tudor facings: authentic hand-moulding could not meet their demands and, after the First World War, the first machine-made rustics, artificially textured, appeared. In the 1950s and 1960s architects sought blue, grey and red facings but now they have reverted to multicolour stocks and the hard smooth reds of earlier times. As the range of facings is now wider than ever, brickmakers must be alert to changes in fashion.

Since 1965 changes in legislation regarding thermal insulation in buildings have led to the replacement of common bricks by various kinds of concrete block, and in the late 1960s many yards specialising in commons closed down. The high value of facing and engineering bricks encourages greater investment in new manufacturing plant.



ABOVE LEFT: Fragments of Roman brick.

ABOVE: 'Great bricks' of the twelfth and thirteenth centuries.

LEFT: Fifteenth-century bricks.

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PLACES TO VISIT

Brickworks usually welcome visitors, either singly or in small groups, by prior appointment. Disused brickworks are usually on private land and permission to visit should be sought from owners. This can sometimes lead to discovering useful information about the history of the site.

Restoration work is proceeding at a preserved nineteenth-century brickworks at Blists Hill Open Air Museum at the *Ironbridge Gorge Museum*, Ironbridge, Telford, Shropshire. Telephone: 0952 586063. A drying shed from a brickyard at Petersfield, Hampshire, has been re-erected at the *Amberley Chalk Pits Museum*, Houghton Bridge, Amberley, Arundel, West Sussex BN18 9LT. Telephone: 0798 831370. This houses a collection of bricks and hand-moulding equipment. There is a restored scotch kiln with a collection of brickmaking artefacts at Baumber Brickyard, Baumber, Horncastle, Lincolnshire LN9 5NW. Telephone: 065887 330. Brick buildings and brickmaking machinery can be seen at Avoncroft Museum of Buildings, Stoke Heath, Bromsgrove, Worcestershire. Telephone: 0527 31886 or 31363. Many museums in brickmaking areas have collections of local bricks and brickmaking equipment.

Early kilns have been preserved at Collier's brickworks, Marks Tey, Essex; Nettlebed, Oxfordshire; Powerstock Common, Bridport, Dorset; Kiln Cliffs, Mundesley, Norfolk; and Walmer Road, Notting Hill, London. Not all are officially listed as industrial monuments but some survive because they have been put to other uses. There are doubtless other examples. Negotiations are progressing concerning several continuous kilns.