INTERNATIONAL EXHIBITION, LONDON, 1871.

POTTERY.

OBSERVATIONS ON THE MATERIALS AND MANUFACTURE

OF

TERRA-COTTA, STONE-WARE, FIRE-BRICK,

Porcelain, Earthen-Ware, Brick,

MAJOLICA, AND ENCAUSTIC TILES,

WITH

REMARKS ON THE PRODUCTS EXHIBITED.

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PREFACE.

In making a brief report upon the Pottery displayed in the Exhibition, relating to objects of use and ornament in every house and family, the opportunity presented itself to examine the processes of manufacture employed in the principal branches of the ceramic art.

In describing these, I have endeavored to add to the enumeration and treatment of the materials employed, a summary of their different qualities for their respective uses, together with analysis drawn from reliable sources, and a slight sketch of the origin and progress of these great industries.

To render the subject more intelligible, I found it impossible not to enter somewhat into technical details, which I hope will not prove wholly without interest.

Arthur Beckwith.

INTRODUCTION.

The International Exhibition, held this year in London, contains a very complete collection of Pottery in all its branches. The machinery employed in its manufacture is also exhibited, but only to the extent of a small portion of the various machines employed.

The following pages contain a notice of the principal objects of interest in each department, and a summary of the various processes of manufacture, with the differences between them.

The composition of almost every kind of Pottery is frequently guarded as a trade secret, but of late years, with indifferent success. The materials available in each locality, which form the basis of local manufactures, differ in their chemical element, and especially in the mode of their aggregation. In Pottery, the mode of aggregation or grouping of the chemical elements, exerts an all-important influence (see Fire-brick), and even when the exact composition of a ware is known, it cannot be reproduced by merely bringing together in correct proportion, the right chemical elements. To use the different available materials, direct experiment with them must be made from the start; and as the substances extracted from the earth vary from year to year, these experiments must be repeated subsequently, in order to maintain the quality of the products.

In the presence of modern chemical analysis and microscopical research, it avails little to keep secret the composition of wares. Analysis reveals the proportion of the primary elements; the microscope goes far to determine their mode of grouping; and as to the choice of natural materials, this is inevitably, even when the composition is known, the subject of direct experiment.

POTTERY WARES.

Before proceeding further it may be well to recall that the term Pottery is comprehensive, including all things fashioned of earth and hardened by heat, from the rough baked clay in the shape of bricks and massive articles, to the fine china clay worked up to the lightest and most transparent porcelain.

The term Pottery, as distinguished from Porcelain, is sometimes used to indicate only opaque earthen-ware, but the variation in the degree of transparency of semi-vitreous substances is so gradual that the boundary line determining where the one ends and the other begins cannot be well traced.

All pottery wares may be divided into *unglazed and unvitrified ware*, which is absorbent and permeable to water, and *glazed and partly vitrified ware*, which is non-absorbent and impervious. At an early period, glazes consisted of a coating of wax or oil and ochreous earth, or an alkaline solution to vitrify the surface, until the discovery of an adherent vitreous glaze, which could be fused upon the surface of the porous clay. Later, in Southern Europe, a glaze composed of silica and lead was used, and the Moors, by adding oxides of lead and tin to glass, formed an opaque white enamel, which was imitated in Italy, and various metallic colored enamels were discovered.

Pottery wares may also be divided into *hard* and *soft* ware, according to the materials used and the temperature at which they are solidified in the furnace, which results in a marked difference of texture. Thus common brick and earthenware are soft, while fire-crockery and stone-ware are hard. And porcelain, likewise, is either like the hard Oriental china-ware, or the soft English porcelain, which receives its greatest fire in the biscuit or unglazed condition. Hard porcelain was known to the Chinese many years B. C., and imported into Europe by the Portuguese about the year 1500, but its composition remained unknown there until, in 1709, Böttcher, in Saxony, accidentally discovered it, and Cookworthy, in England, discovered the china clay.

PORCELAIN.

Excellent qualities of china clay are found in Cornwall, West Devon, Central France, Northern Germany and America; they all seem without exception to be formed by a process of natural or artificial washing from the decomposed felspar of certain kinds of granite. Felspar contains 62 silica, 20 alumina, 15 potash, and 3 of water, lime, magnesia and iron. The materials from Cornwall are artificially prepared, and the uniformity of quality thus obtained makes them more valuable than the natural china clay which varies more in quality. One hundred parts of the finest china clay, or kaolin, contain: Silica 46, alumina 40, oxide of iron, lime, magnesia together 1, water 13. When more silica is present, especially in a free state, as fine or coarse sand, 10 or 12 per cent. of which is sometimes found mixed in the clay, as in Cornish stone, the china is rendered coarser.

The process of natural washing of porcelain clays has been performed on a large scale in Cornwall and Devonshire. The decomposed granite has been washed through an extended valley, leaving the coarser particles of quartz behind, and conveying only the particles of fine clay to the lower parts of the valley, where they are found covered by a bed of local gravel. These deposits are cut with a spade into cubical blocks called "china stone," and partially dried and removed, leaving large pits.

When the kaolin is artificially prepared, the decomposed rock is washed in a series of tanks, in the first of which the heavier particles of quartz, mica, and impurities are collected, while the fine particles, consisting of the decomposed felspar, are allowed to settle in the succeeding tanks. The water is run off, the sediment is dried in sheds and cut into cubical blocks of about one foot, and sent to market.

The soda granites, in which the felspar contains soda instead of potash, decompose most readily and are most used for porcelain.

There are differences in texture and appearance between the English porcelain called "china" and the "hard porcelain" manufactured in China, France, and Germany. The body and glazes of hard porcelain are composed of the same purely granitic materials, used only in different proportions, and under the very high temperature employed they vitrify together. As this high temperature would be destructive to coloring, the colors are laid on over the glaze subsequently to it, and fixed by again firing at a lower temperature. The result is a certain dead opacity in the appearance of the coloring.

The composition of English or soft porcelain is more complex; a large proportion of calcined bone is mixed with the china clay and Cornish stone to produce an effect of white transparency, and small proportions of gypsum, sand, chalk, alum, soap, soda, lime, nitre, and salt are added. This body receives its strongest firing first, and the glaze and colors are then applied and fired at a lower heat. The glaze is formed of oxide of lead or tin, with borax and silica, potash or soda, resembling that of old Sèvres. This glaze vitrifies separately from the body, and forms over it a coating similar to glass; it sometimes incorporates the colors in such a way that the subjects painted over it appear through the glaze as under a glass, presenting a brilliant and finished appearance, like the soft Sèvres porcelain of the last century.

The hard porcelain differs from the soft in being closer grained, denser, more translucid, capable of supporting greater heat, presenting many crystalline specks in the fracture, and its glaze is harder, not so easily scratched by the knife, and incorrodible by acid. Hard porcelain is not manfactured in England; twenty years ago Messrs. Minton tried to manufacture it, but abandoned the attempt.

The nature of the fuel used in England, which is coal, together with the softer nature of the clays, are attended with greater difficulties than the use of wood, as in France. There are some advantages in the matter of colors in making soft porcelain, for turquoise, Bleu de Roi, and transparent green can be freely employed on English china, and they have more brilliancy, especially by candle-light, than the colors of the hard porcelain. The fusibility of the softer lead glaze, by incorporating the colors, produces this transparency. The plasticity of the body also allows of greater perfection of form, and it is of a purer white.

Analysis of English porcelain, by Couper, show a composition of:

Silica	40 per cent.			
Alumina	21	to	25	per cent.
Lime	10	"	14.22	"
Magnesia	0	"	0.43	"
Phosphate of lime and some iron.	26.44	"	15.3	"
Alkalies and loss	2	"	6	"

The bones used are chiefly imported from South America. Those of oxen are best, those of horses and hogs contain too much iron. They are deprived of grease by boiling in hot water, then calcined openly or first distilled in closed vessels and then burnt in contact with the air. The white ashes are ground and tempered before use. This phosphate of lime has a strong whitening power, and is considered to act mechanically to form the skeleton of the ware. As much as fifty per cent. is sometimes introduced.

The biscuit fire lasts twenty-five to fifty hours, and is conducted in kilns, similar to those for earthen-ware. The fire for the glaze lasts fifteen to twenty hours.

The glaze contains:

Oxide of lead	20	to	23	per cent.
Oxide of tin	0	"	3	"
Cornish stone	20	"	33	"
Flint	7	"	17	"
Flint glass	0	"	20	"
Crystallized borax	19	"	25	"
Soda and potash	0	"	8	"

and instead of Cornish stone sometimes thirty-eight to forty-two per cent. of felspar. A fraction of smalt is occasionally introduced.

The elements of hard porcelain are kaolin fluxed with felspar. Examined under the microscope this porcelain shows a framework of minute opaque particles of burnt kaolin, cemented by the fluxing elements, which are fused to a transparent glass (Ehrenberg). Occasionally, to diminish the shrinkage, quartz sand or ground porcelain are added, and to increase plasticity, the alumina is increased.

When felspar is wanting, there are substitutes, such as pegmatite (a granite), dust from granitic roads, kaolin melted up with carbonate of potash, gypsum and chalk. The materials are ground particularly fine and well washed. All the devices of kneading, balling, beating, etc., which produce an intimate and homogeneous mixture, are applied. Warm water, which dissolves earths and alkalies, is recommended to remove those causes of softening.

The analysis of porcelains from China, Sèvres, Berlin, Dresden, etc., show a composition between :

Silica	53 to 75 per cent.
Alumina	18 " 35 "
Potash	0 " 5 "
Soda	0 " 3 "
Lime	0 " 5 "
Magnesia	0 " 1.5 "

Iron, as little as possible.

Laurent analyzed the best chinas, and the composition he found has since served as a model at Sèvres, viz. :

Silica	58.
Alumina	34.4
Lime	4.5
Potash	3.

In Vienna, 72 per cent. of kaolin was fluxed with 12 felspar, 12 quartz, 4 gypsum. The Dresden china contains even 26 per cent. felspar.

The glazes of Dresden and Munich are formed of :

Burnt quartz	35 to 37.
Kaolin and ground porcelain	46 " 48.
Limestone and gypsum	16 " 18.

The glaze of Sèvres is simply pegmatite, which contains silica, 76, alumina, 16, potash, 8. The glaze used being of the same composition as the mixture which fluxes the kaolin, it readily unites with the latter in the fire, and porcelain can be made in one firing, as in china, the object being moulded, painted and glazed in the clay state, and completed in one firing.

It is usual, however, to heat the body first to 30° or 60° Wedgwood, so that it may rapidly absorb the water of the glaze when subsequently dipped in it. The degree of this first heat requires attention, for if too high the ware will no longer absorb the glaze. By greasing any part, it will not take the glaze. The second firing requires the strongest heat used for any pottery (130° to 160° W.), to obtain a sufficiently hard glaze, and great care in modulating the heat. The total shrinkage reaches up to 17 per cent., the quarter of which occurs in the first fire. The ware must be separated from the products of combustion.

The ovens are various. The Ginori or Sevres Oven, is in three stories, the two lower directly heated by fires at the sides, the upper one by waste heat. The Berlin Oven has 4 stories, the lower one is used exclusively as a combustion chamber from which the gases ascend to the three others successively. It is said to give higher heat than the Sèvres. Among the best are those fired with gas; the preceding one, and that of Thomas, are somewhat of this kind, the flame being direct, but those of Venier and Gustavsberg are more perfect. They resemble somewhat Bosch's oven (see Stoneware.) The gas generator is separate and under perfect control; the gases are introduced in the centre of the floor of the oven, ascend, are reverberated, and drawn through 18 apertures in the floor into flues in the outer walls, which lead to a second story chamber, and thence to a third, where a central chimney exhausts them. Preliminary heating of the air produces a higher temperature. An analogous oven is being tried at Berlin, in which the successive chambers are placed side by side, instead of being superposed. This disposition allows of the continuous principle being applied, as by Hoffmann.

There is still room for improvement in porcelain ovens, since 1 lb. of porcelain requires the heating of 15 lbs. of other material, irrespective of the masonry of the ovens, for all of which, 8 lbs. of coal are necessary.

Porcelain Exhibited.—In examples of common English pottery, the mere manufacture is of the highest and soundest quality, though the design and harmony of colors are not unfrequently deficient in comparison.

The high technical excellence of modern ceramic art is well represented at the Exhibition.

Dr. Wall, the founder of the Royal Worcester Porcelain Works, first turned to account the discovery of Cornish stone, and these works exhibit very fine porcelain; especially of a dark blue color. In decoration they have avoided the use of too great diversity of color in the same work; the brilliant positive hues they use, in connection with the human figure, have been objected to as less effective than half tints. The transparency of their porcelain is noted. Their Parian is admired, and they also exhibit Majolica.

Copeland & Sons make a fine show of porcelains. Their most successful colors are a purple and a rich green. A novelty in their decoration consists in small subjects and figures in black, traced out with a fine gold line on a white ground, having the effect of a Silhouette.

In coming to the name of Minton it is proper to recall that there are three firms, Minton & Co., Minton, Hollins & Co., of Stoke-on-Trent, and Robert Minton Taylor, of Fenton, in the same vicinity. The specialty of the two latter is flooring tiles, though they exhibit other goods.

Messrs. Minton & Co.'s specialty is not flooring tiles, which they do not manufacture, but they exhibit largely in all other descriptions of earthen-ware and porcelain. Mr. Thomas Minton founded the firm in 1791, and to the labors of his son, Mr. Herbert Minton, are due in great part the medals which the firm acquired at all the exhibitions. The present proprietor is Mr. Colin Minton Campbell. Mr. Arnoux directs the staff of artists who assist the firm. The excellence of their colors, and the variety in the kinds of ware they exhibit, place them among the first manufacturers.

They obtain a new process of gilding by corroding the glaze with an acid and applying gold leaf upon the body.

The revived and modified Orientalism of ceramic decoration first in Paris and now in London, is a notable feature. Oriental surface decoration seems to have due regard to the right principles, as it is always pleasing. The Persian ware of Minton's is one of the novelties of the Exhibition. Its brilliant blue rivals the turquoise in richness and texture. The brothers Deck, in Paris, first revived this art. A pair of céladon vases by Minton, on pâte changeante or chameleon ware, which from gray green by day changes to a deep pink or crimson hue under artificial light, and enriched by some delicately executed Cupids, are admired.

John Mortlock's turquoise blue is as fine as Minton's, but the glaze applied is defective from being crackled by unequal expansion.

The names of Wedgwood, Pellatt, Goode, Adams, Kerr, Phillips & Pearce, Powell & Bishop, Rose, Battam, Boucher Guy, Hancock, Garrard, Elkington are also prominent among English manufacturers.

Italian, Spanish & Portuguese pottery are exhibited by the Science and Art Department. The Italian and Spanish wares exhibited are defective in coloring and glaze. The Portuguese Palissy ware shown is highly glazed, but presents a striking example of utility made subservient to decoration.

A collection of Moorish ware, lent by Mr. G. Maw, shows good forms and tasteful ornamentation. It is said that the history of the potter's art is the history of civilization, and in this sense the Egyptian pottery, lent by the Khedive, is interesting. It shows a coarse body and inferior coloring, but the forms are quaint and graceful. The yellow glaze used at Old Cairo consists of oxide of lead and pounded pebbles of silex. The green glaze contains copper in addition. The body is formed of clay mixed with ashes, sand,

and sometimes hemp, and slime of the Nile. Likewise Indian pottery is curious and instructive in form and color. In some specimens gray or brown mica mixed with the clay, or rubbed on it, produces a metallic effect on the surface.

Canada contributes some pottery of a common description.

Danish pottery is well represented. The Royal Copenhagen Manufactory has a high reputation, and Bing & Gröndahl exhibit good work. A plate pattern, of tendrils and flowers lightly sketched on a ribbed surface, is admired. This decoration is of a simple and pleasing kind, and in better taste than more elaborate and expensively painted dishes, in which the idea of actual use seems out of place.

Hungarian porcelain, exhibited by M. F. de Farkashaza, ornamented with a light red design on a light-colored ground, is admired in the same way for its pleasing effect and good taste. The porcelain is of a fine quality, and very hard, produced at Herend. The ornamentation has a peculiar and somewhat Japanese character.

The body of the Swedish porcelain is good and hard; the correctness and grace of the decorative wares are characteristic.

Prussian pottery is represented by some very fine white biscuit or unglazed ware from the Royal Berlin Porcelain Works, and an Urbino vase, price $260, of great beauty and richness of coloring. The porcelain is hard, and noted for the precision of manufacture.

Some Belgian dishes are shown, profusely covered with paintings of merit as works of art, but which may be reproached with the common error of making the use subservient to the decoration. Several Danish, Swedish, Hungarian, English, and other exhibitors have happily avoided this extreme.

As novelties, the smoke-painted porcelain from Berne, executed by Mme. A. Leuzinge, and a set of photographs of landscapes on porcelain plates by Leth, of Vienna, are pleasing specialties.

Also W. J. Goode, of South Audley street, London, exhibits etchings on the glaze, of special merit. The designs are eaten into the glaze with fluoric acid, so that they could be printed from ; and the lines thus produced are colored.

PATE-SUR-PATE,

Or " clay-upon-clay." In this method of decorating porcelain, the actual ornament is produced by the application, with the brush, of white liquid porcelain, or " engobe," used as a pigment, in successive layers upon the colored body of the ware—*i. e.*, a given thickness is added to it, with a brush or by immersion, presenting a rough surface in relief, which is trimmed to the required design by cutting implements and sharp scrapers. By successive applications, the painter, who requires to be also a modeller in the treatment of his subject, gains his effect of relief. When the bas-relief is completed, the object is subjected to several bakings or firings, and at the last firing it is covered with a coating of glaze. The strong oven fire vitrifies the porcelain and the pigment, embodying them together, and rendering the salient objects translucent. These portions, in vitrifying, retain a relief which forms the actual outline and the high lights, while its thinner parts enable the colored groundwork to be seen through them, and these form the transparency of floating draperies, clouds, or flesh, according to the design.

The principle of pâte-sur-pâte thus differs from that of ordinary white porcelain transparencies used for lamp and window decoration, by transmitting color through the design instead of light.

The clay ground generally used is a soft yellowish gray or sage green, known as céladon. The tint is tender and unobtrusive, and its effect, seen through the thin parts of the superimposed design, is pleasing. Like most European novelties, however, it is an old acquaintance of the Chinese, from whom the idea has been derived. Pâte-sur-pâte was first attempted in Europe in 1847, at Sèvres, under Ebelmen, and until the late war many articles in this style were produced of great beauty. During the siege of Paris, Messrs.

Minton secured the services of Mr. Solon from Sèvres, and at once began experimenting to obtain the colored clays required. They met with complete success, obtaining the Sèvres colors and several others in addition, and now produce céladon cups and vases, graceful in form and delicate in execution.

Mr. Solon's work possesses a cameo-like softness, which yet harmonizes well with the somewhat coarser grain of the body of the ware. Mr. Burty, in his "Chefs d'œuvres of the Industrial Arts," says of this artist: "Mr. Solon, who also signs his delicate bas-reliefs with the word "Miles," is gifted with a perfectly modern sentiment for decoration. These nymphs who push aside the reeds of the brook; these Psyches who are lighting a Diogenes lantern; these water-nymphs reclining on the brink of the waters which flow from their bended urns; these chimeric figures which stand erect with bulging throats; these Medusas whose hair is composed more of strings of pearls than of snakes,—these are the dreams of an artist born in our day, and who only claims of Antiquity or the Renaissance the more exquisite details of their fancy."

The prices set upon Mr. Solon's work, are $90, $70, $110, for three vases respectively 7, 10 and 18 inches high.

The very high temperature employed in firing this ware, is destructive to most colors, and only those obtained from the oxides of cobalt, nickel, chrome, uranium, etc., are used. Specimens are shown with a ground of a warm chocolate color and other dark colors. The effect of these is apt to be flaky and less delicate. One of the difficulties, when figures are delineated, seems to be that the glaze has a tendency to mar the effect by destroying the sharpness of outline. Oxide of chrome, fired in a neutral atmosphere, produces Céladon green.

In the Limoges ware, the difference is that a regular enamel or vitrified pigment is used, while in pâte-sur-pâte, porcelain clay merely is used.

"PATE CHANGEANTE."

Another peculiarity of the Sèvres work is their "pâte changeante" invented by the director, Mr. Regnault, and so named from the color changing from grayish céladon by daylight, to a decided pink by candlelight. Messrs. Minton have succeeded in producing a similar dove color, which changes to a light crimson by artificial light. Oxide of chrome, fired in an oxidizing atmosphere, produces a similar color.

GRAFFITO WARE.

This ware recalls by its decoration, that of the walls of Pompeii; from the objects exhibited, and the simplicity and beauty of their ornamentation, it promises to develop well.

Graffito, which means scratched ware, is of Italian origin, and is supposed to have been first invented in the province of Perugia in the 15th century. At the period of the Renaissance in Italy, the potters, ignoring the decorative processes with colors and enamels, then familiar to the Moors in Spain, and which Della Robbia subsequently imitated, made use of two clays of different color. The body of their vessels they formed of the darker clay, and after drying them only sufficiently to be able to handle them, they dipped them into a liquid "slip" formed of the lighter colored clay. As soon as this coating was dry, the artist, with a sharp wooden or steel point, traced his ornament on the surface, removing the upper light-colored surface and showing everywhere on the lines of the design, the dark body beneath. The vessel was then covered with a natural sulphuret of lead ore previously triturated, which, when fired, melted on the ware and produced a rich yellow glaze. This process of decoration allows the artist to express his feeling on the ware without the intervention of any assistants. After firing, some parts of the work were touched up by the application of slips of copper or manganese ore, which produced the green or violet patches which give additional richness to the ware. The natural colors of the clays, which form the decoration of this ware, generally harmonize perfectly together and consequently produce a good effect. Messrs. Minton & Maw have lately revived this process, and show fine specimens. Minton's designs are by W. A. Stevens.

HENRI DEUX WARE; OR, FAIENCE D'OIRON.

Henri Deux ware is the only description of pottery in which clays of different colors are inlaid together. The artist having made his design, each distinct part of the ornament is stamped on separate "bats" of clay. The design is thus indented in the soft body of the ware and this indentation filled up with another colored clay, and when dry the superfluous clay is removed from the surface. The separate bats are then placed into their proper forms side by side, in a complete mould, and a backing formed of a general coating of clay was applied to unite them together. The plastic state of the clay required great care not to distort the design.

Though this process is very similar to the 12th century art of tile making, yet the application of the encaustic process to vessels of delicate size and complicated forms was not attempted till about 1540. It is held in high esteem, and valued above its intrinsic merit on account of the scarcity of the original examples; its revival by Minton is all the more interesting.

The ornaments of Henri II. ware are in the Renaissance style, and the forms have a metallic rather than fictile character.

A toilette suite ordered by Henri II. for Diana of Poitiers is all that is said to have been originally manufactured; Mr. Chaffers gives a list of the pieces known, of which there are only 53, namely 26 in England, 26 in France, and 1 in Russia. The bowl that Sauvageot left to the Louvre was bought by him for 200 francs. In 1835, the ewer possessed by De Monville brought 2,500 francs. A salt-cellar at the Rattier sale, in 1859, brought 12,500 francs. A restored candlestick, plainly ornamented, went for 16,000 francs at the Lafayette sale, in

1862, and the Science and Art Department of the Kensington Museum gave 18,000 francs for it. Finally, at the Pourtales sale, a biberon was bought by Mr. J. Malcolm, of London, for 27,500 francs. Such were the values set on the original Henri II. ware, and now for a comparatively moderate outlay possession may be had of reproductions by Minton, quite equal to the originals. Although Minton & Co. have not attempted to copy the exact tint of the clays, their specimens prove that they are fully acquainted with the process. Mr. Charles Toft is the name of the maker.

POTTERY MOUNTED IN DAMASCENED METALS.

Senor Suloaga, of Madrid, is the only producer at the present day of the Damascene work of the Saracens, and in 1855, he exhibited a fine display of damascened fire-arms.

He now exhibits, in connection with Minton & Co., a combination of pottery with this metal work which is very effective.

CLOISONNE ENAMEL.

A specialty undertaken of late years in Paris is the reproduction of Chinese and Japanese cloisonné enamel. In this Oriental work, a vessel of metal, usually copper, is first made and the lines of a pattern traced on its surface. A fine wire beaten into a flat supple riband is then taken and soldered by one edge to the lines traced on the surface of the copper vessel. The wire stands on its edge, forming a number of cells or cloisons which are filled with a paste composed mainly of oxide of lead and silica, with some lime and soda, and colored as required, either with the oxide of copper, iron or cobalt. The vessel is then fired at a heat sufficient to vitrify the paste, and finally the whole surface is polished by friction.

The character of the Chinese cloisonné work is coarser and bolder than that of the Japanese, and in both the contrasts of colors are successfully harmonized. Barbedienne and other Paris makers have made very graceful work of this description.

A novelty undertaken by Messrs. Minton, is their imitation of the above cloisonné work, using only porcelain instead of metal, and painting on it with colors which have been mixed with opaque enamels, as practised also in China. This method of decoration is very effective, except when the attempt is made to imitate metallic cloisonné work, which is more subdued and sober in tone and glaze. The soft nature of English porcelain lends itself to the production of great richness and depth in turquoise color, when the body is covered with turquoise enamel; when appropriately decorated with colored enamels, the effect is admirable.

UNDER-THE-GLAZE PAINTING IN OPAQUE ENAMEL COLORS.

Messrs. Minton have introduced a new set of materials for painting on a densely colored body, in the same manner as body colors are used in ordinary painting; the whole can be subsequently glazed over without affecting the most delicate touches. Mr. Mussill, their artist in this department, was acquired by them since the late French war. The colors are perfectly opaque, have the appearance of colors for canvas, and have much more body than the ordinary colors for painting on porcelain. By firing they do not change or sink, and retain the spirit of the brush. They withstand perfectly the action of the glaze in the glost oven.

This method of painting (see Chinese Porcelain), practised in the East, has since been imitated at Dresden, and lately been revived at Sèvres and Stoke-on-Trent.

The advantage it presents, of depth of tone in colors, durability owing to hard firing, and economy of manufacture, since the decoration can be applied and made fast at one firing (unlike the paintings on porcelain, that frequently require several firings), make it desirable that this method should come into more general use.

To produce these colors, the following considerations may assist. They are obtained by mixing opaque enamels in the colors. The different colors must act alike in withstanding a hard fire, and fusing at the same high point; in adhering to porcelain or stone-ware, and in taking the glaze uniformly.

To obtain the requisite opacity, oxide of tin, oxide of antimony, phosphate of lime, oxide of lead with some salt, alkalies and silica, and in general the enamels applied to majolica, fayence, and stone-ware, are available. The metallic oxides which supply the color, act as a flux upon the enamel, and tend to increase its fusibility. Only those oxides should be used which will stand a strong heat, and, like the oxides of iron, cobalt, chrome, titanium, uranium, manganese, and chromate of iron, possess strong coloring powers, and in consequence do not require to be used in quantity large enough to fuse the enamel too soon.

To diminish the fusibility, the steps taken in the manufacture of fire-bricks and of majolica enamels (which see), apply. The fritting of the glaze (*i.e.*, preparatory melting up to a glass), and sudden immersion while hot in cold water, increases its refractory power, and heightens its crystalline lustre. In Berlin, white glass ground is used as an ingredient for stanniferous enamels. If the colors used are fat, the object should be heated to volatilize the fat substance before applying the glaze.

PERSIAN WARE.

The old, not the modern, Persian ware is distinguished by a special brilliancy and effectiveness of colors. Messrs. Minton, Maw, and Minton Hollins have attempted to attain the richness of vitrified colors characteristic of this ware, and in adopting Persian patterns on turquoise and plum-colored enamel grounds, they have met with considerable success in their reproductions. Messrs. Deck, of Paris, were first prominent in this line.

According to Scheill, the Persian body contains silex, oxide of lead, and kaliab; and the Persian glaze consists of 50 white silex and 40 kaliab (ashes of a plant growing on salt soil); it is fritted, powdered, and mixed with gum and syrup.

CAMPBELL'S PATENT MOSAIC WALL DECORATION.

In this process, also called Permanent Fresco or Fictile Vitrification, the material for painting on consists of a number of small hexagon pieces in stone-ware, highly vitrified, and joined together in placques of convenient size by a vitreous cement.

This ground is painted on in the new opaque enamel colors, prepared to stand a very high heat, to secure the permanency of painting in any climate. Curved surfaces can be easily managed. The inventor, Mr. C. M. Campbell, is now casing the ceiling of the staircase of the South Kensington Museum after designs of Mr. Moody. Two specimens of this novel work are shown, executed by Mr. Thomas Allen. A permanent surface hitherto used for fresco work has consisted of wide placques of pottery ware, but the warping of these in the furnace has presented obstacles which this invention is adapted to overcome; the shrinkage of each pellet being small, the general proportions are preserved. The process still remains to be tried, applied to a large surface.

BELLEEK WARE.

The Belleek ware from Ireland is a new appearance. Sets of tea-cups and saucers of an original character are exhibited by Mr. Mortlock.

The Belleek ware is distinguished by the high lustrous silvery quality of the glaze, which attracts the eye, and recalls the nacreous coating of a sea shell. Table ornaments of this ware are shown imitating shells in form and translucency. The material used is a group of different colored clays, found recently at Belleek, in Ireland, some of which possess the property of yielding upon firing, a natural enamel or "skin" like the finest egg-shell porcelain. The glaze is iridescent, like mother of pearl, and requires to be used with discrimination for decorative purposes.

Messrs. Kerr, Phillips & Pearce, and the Royal Worcester Works, produce similar ware, in which the glaze is probably one of the artificial glazes invented by Brianchon, in which the lustre is obtained by the reduction at a low heat of metallic substances such as nitrate of bismuth, iron, uranium, nickel, and cobalt, or chloride of gold, by an excess of carbon, introduced in the glaze in the shape of resin and essential oils of lavender or turpentine, and formerly by a reducing atmosphere of smoke. The thin metallic deposit, like all films of great tenuity, decomposes the light falling upon it into prismatic colors. The lustre is applied with a brush, thinly, and should not be absorbed by the ware. After firing at a low heat, it adheres to the surface, and does not incorporate itself with the body like ordinary glazes. At an early period, wax and mastic were used to procure the adhesion of the lustre.

JASPER WARE,

More popularly known as Wedgwood ware, differs from pâte-sur-pâte in the method of applying the clay, which is usually white clay squeezed into moulds and then withdrawn to be attached to the surface of the body of the vases; the ware is not glazed; it has no more vitreous appearance than is produced by the hard fire on the mixed clay body, and presents a dead texture. The ground may be of any color. Josiah Wedgwood invented jasper ware, and the firm of Wedgwood & Co. is constituted by his descendants.

Although Wedgwood ware presents less varied and subtle effects than pâte-sur-pâte, yet the outline of the relief is generally more perfect. Most of the designs used by Wedgwood & Co., are Flaxman's; and the beauty of their ware with blue, dove, or olive colored ground is well known. Jasper ware may be defined as a superior quality of vitrified stone-ware. It requires more careful preparation, and is formed of a plastic clay to which vitrifying ingredients such as Cornish stone, flint, ground glass, felspar, sulphates and carbonates of lime and of barytes (L. Arnoux) have been added.

According to Salvetat fine yellow Wedgwood ware consists of:

Silica	66.49.
Alumina	26.
Oxide of iron	6.12.
Lime	1.04.
Magnesia	0.15.
Alkalies	0.20.

White jasper ware contains variously 15 to 30 per cent. of plastic blue clay, 0 to 15 kaolin, 0 to 15 Cornish stone, or, summing up, 40 to 50 per cent. of these clay materials; to which is added 25 to 45 per cent. heavy spar, 0 to 10 flint, and 0 to 2 gypsum. Sometimes 20 per cent. calcined bone is introduced. This white body may be differently colored by metallic oxides, ½ per cent. cobalt giving blue, with 1 per cent. chrome dark green, nickel light green, copper bluish green.

From natural ochreous clays and quartz a reddish porphyritic jasper ware is made.

Basalt ware, susceptible of high polish, and Egyptian ware are made by introducing in the body some 40 per cent. of burnt ochre, or 16 per cent. ochre and 45 of red clay, and sometimes 10 per cent of mill cinder (iron).

CHINESE PORCELAIN.

The researches of Ebelmen and Salvetat have revealed the distinct characteristics of Chinese Porcelain.

The body is felspathic and hard; the glaze is softer than that of European hard porcelain; the colors are properly enamels, transparent or opaque; the coloring oxides are very few. The whole is made in one firing, at a somewhat low heat.

The ware of M. Lesme, of Paris, is similar.

The enamel colors are crystals (composed of 6 minium, 2 sand, 1 borax melted, and some soda and potash) holding in solution a few hundredths of coloring oxides. The fundamental colors are very few, viz., cobalt for blue, copper for blue and green, gold for carmine, antimony for yellow. All other tones, with one or two exceptions, are obtained by mixing these.

The harmony of Chinese decoration results from the restricted number of coloring agents. The brilliancy results from the oxides being dissolved.

For opaque enamels, white of tin or arsenic are used. The crystals are faintly colored and rubbed in water only. For deep tones they must be superposed several times, hence the relief observable. These enamels could not adhere upon a hard European glaze. Their adhesion is attributed to the peculiar nature of the glaze.

The glaze is complex; kaolin stone, vegetable ashes, and lime are used, resulting in silica 68, alumina 12, lime 14 to 21, potash and soda 6.

The moulds, even for delicately embossed pieces, says Arnoux, are simply clay moulds dried in the sun.

The walls of the ovens are so thick that the hand laid on outside at no time perceives the heat. The volume of air entering is regulated; the fuel is dry wood. When the fire is started the door of the oven is closed, leaving only room enough to insert one piece of wood. The heat is gradually raised for 30 hours. At Sèvres, to increase the plasticity, the following body, called "masse Chinoise," is used for large objects (Regnier): Kaolin clay 43 to 44, plastic clay of Dreux 21 to 25, sand from kaolin 16 to 17, quartz sand 16 to 9, chalk 4 to 5.

PARIAN.

Parian, like stone-ware and terra-cotta, is composed of clay mixed with vitrifying ingredients, but it differs from these, both in aspect and composition, as being composed of purely granitic materials. In composition, it lies between stone-ware and English or soft porcelain. Unlike the latter, it contains frequently no calcined bone, and shrinks more.

The clay used is the Cornish clay (obtained, as previously described, from decomposed granite) and undecomposed felspar, which, being rich in soda or potash, acts as a flux. It is obtained from America or Sweden. The result of firing is a semi-opaque translucent substance known as Parian, and in which every sharp outline is retained. Copeland first made it in 1848.

Salvetat gives the following composition of Copeland's Parian, before burning and after:

Silica	58.51	63.74
Alumina	21.	29.71
Oxide of Iron	1.	——
Lime	0.14	1.41
Magnesia	0.05	0.41
Potash	11.40	——
Soda	5.08	4.39
Loss	6.40	——

Ovens for earthen-ware can be used. Continental Parian is often of a bluish white tint; this arises from the partial exclusion of air from the ovens, and consequent reducing atmosphere (see Blue-bricks). English Parian is of a pleasing creamy color, owing to the abundance of air in the oven, which peroxidizes the small quantity of iron salts disseminated through the mass.

Parian figures are produced from this mixed clay poured in a fluid condition into plaster moulds; the vitreous nature of the substance renders the subsequent firing a crucial test. The contraction in baking amounts to $\frac{1}{4}$ usually, sometimes even $\frac{1}{3}$ of the original dimensions; due weight should, therefore, be allowed for the variable allowance the artist has to make for the shrinkage of his work.

There are many other ways of making Parian. If plaster of Paris, in fine powder, is thrown in a vessel containing a saturated solution of borax, after soaking for some time with a solution of alum a hard plaster is obtained (Ansted), which is also called Parian, although differing in composition from the above.

Copeland & Sons exhibit well modelled forms in Parian, showing fine workmanship, as well as material of great merit.

The Royal Worcester Works produce pretty statuettes.

Swedish Parian, made from Cornwall clay, by the Gustafberg's Co., is very white and hard.

Danish Parian statuettes, by Bing & Gröndahl, attract attention; the excellent plan of attaching the selling price to each article, which all exhibitors are invited to adopt, has been followed by them and others, in consequence of which many of their products have been sold.

Parian of inferior texture and form is so common, that its popularity for sculptural works has been much injured; nor can it be compared with carving or sculpture as an art process. The Parian of Minton, Worcester, and Copeland is sometimes glazed to facilitate cleaning. For centre-pieces, baskets, teapots, etc., this is an improvement; but its application to statuary is frequently objected to.

ART APPLIED TO INDUSTRY.

The excellence of ceramic products in the three essentials of material, form, and decoration, is perhaps most remarkable for the two latter qualities, in the examples where the name of the artist accompanies that of the manufacturer.

On one hand, the highest skill in manufactures is constantly seen connected with the weakest efforts of design, as though mere materials and workmanship were sufficient without the quality of art. On the other, much of the best artistic talent is expended upon objects in which we may seek in vain to discover their utility. Many firms rely too much on the quality of their wares merely on account of mechanical excellence of material, rather than upon the artistic treatment which enhances their value. The somewhat cowardly suppression of the names of the artists who design and model the works of various manufacturers, is in a great measure the cause. This practice is less observable in some countries, but it is still only too general.

Employers of skilled labor, who think it their interest to conceal the origin of the artistic element of their manufactures, are doubtless moved by the fear of losing their artists upon revealing their names, or having to increase their pay. But this policy is as narrow as it is ungenerous.

The interests of the artist and manufacturer are not antagonistic; they are parallel. The stimulus of publicity when granted to the carvers in stone, the moulders in clay, the painters on earthen-ware and porcelain, excites their laudable pride and enhances the quality of their work. The mere reward of publicity attracts new artisans to these occupations, and affords the manufacturer a wider choice of art-workmen. An illustrious artist no sooner lends his assistance, than his works are at once eagerly sought.

When an artist has once attained a reputation, the manufacturer who secures his services is generally not unwilling that his name should appear on his products, but it is essential to the development of artistic merit in current manufactures, in its most popular form, that rising art-workmen should have the opportunity of being made known to the public.

In this view and for those interested, I give the following list of Designers and Modellers in the Department of Pottery, which are all the names I have obtained; but before leaving this subject, I must name Mr. Henry Cole, C. B., as the one man in England who, by his foundation of art-schools and museums, and creation of a system of art-manufactures, has done the most to provide art instruction for the people:

LIST OF DESIGNERS AND MODELLERS,

IN THE DEPARTMENT OF POTTERY.

R. J. Morris—employé of the S. Kensington Art School—designed a frieze representing pottery manufacture; also panels representing the months of the year.

WALTER LONSDALE—obtained travelling studentship of Royal Academy—designed art-tile chimney piece.

W. J. GOODE—designs etchings on the glaze.

E. LESSORE (late)—original designs for ornaments in monochrome, free and bold pencil, painted pottery, majolica, cream-colored ware for Wedgwood & Sons.

A. STEVENS—sculptor of the Wellington Monument for St. Paul's; designs Graffito ware, great breadth and power.

COLEMAN—painted heads on earthen-ware for Minton, also mosaic Head of Isaiah.

SOLON—executes pâte-sur-pâte; received at Paris, in 1867, a bronze medal as "Sculpteur en pâte à la Manufacture Impériale de Sèvres." Was the first artist acquired by Minton & Co., possessing the skill requisite to found this branch of industry.

H. DARLING and J. LEESE—engaged in Minton & Co.'s manufactures.

YAHN—painted for Minton an effective frieze on porcelain vase in turquoise-ware, Flying Cupids and Nymphs in the Bucher style, executed before the final glaze.

JOHN GIBBS, J. EYRE, J. P SEDDON—design tiles for Minton.

KATE BRAYFORD—designed mosaic panel for M. Hollins & Co.

LESSELS—mosaic table designed for Maw & Co.

DR. DRESSER—known for his botanical knowledge applied to ornament. Designs conventionalized floral ornaments, ewers, gilt and decorated terra-cotta for Minton & Wedgwood.

D. PEARCE—of Phillips & Pearce; effective design for centrepiece for flowers in Wedgwood ware.

C. F. HURTEN—flowers, birds, skilfully painted for Copeland.

T. H. BOTT (late)—designs after Maclise, for vase, in Limoges enamel manner.

A. DE MOL—Belgium—Battle scenes on porcelain.

E. TOURTEAU—Belgium—Virgin and Child on porcelain.

A. HANSTEL—Belgium—Descent from the Cross, on porcelain.

M. ELDEN—Set of 5 subjects in mosaic, representing the year, for H. Bessemer, Esq. Also art tiles for chimney pieces. Tesseræ, by Maw & Co.

GEO. TINWORTH—modeller, is supposed to have modelled a fine eagle in terra-cotta for Doulton & Co.

J. S. RUSHTON—painted for Worcester Works, Assyrian and Algerian figures on turquoise ground; and the Archangel Gabriel on a placque.

MME. A. LEUZINGER—Berne—Smoke painted porcelain.

ED. RISCHGITZ—paints plates cleverly for Copeland.

JULIUS LETH—Vienna—porcelain with photographic paints.

BALL—modelled colossal terra-cotta figures for Lecture Theatre of S. K. Museum. Doulton, manufacturer.

C. FLEUSE—designed Gothic parapet of terra-cotta, for E. March, Berlin.

O. MULLER, PROFESSOR WOLFF, BLANKENSTEIN—designers in terra-cotta for E. March, Berlin.

MRS. D. O. HILL—a terra-cotta statue of Dr. Livingstone in appropriate travelling costume.

AARON GREEN—painted birds resting on branches of bamboo, on turquoise porcelain for Minton.

M. MUSSIL—Austrian, attained eminence in Paris; now paints under the glaze for Minton.

T. KIRKBY, C. TOFT, W. MELLOR—design graffito ware for Minton & Co.

C. J. ROWE—designed figures of Shakespeare's heroines for Daniel's dessert plates. Also pierced work, and views of "Mentmore," together with R. P. Daniell.

A. WATERHOUSE—designs for Simpson & Sons' art tiles.

C. SMALLWOOD—designed and modelled a bread tray for R. M. Taylor.

S. COOPER—mosaic inlaid in alabaster, for M. Hollins & Co.

T. MORGAN—mosaic "Head of Inigo Jones," in tesseræ, by Maw & Co.

HENRY SHERWIN—designed dinner plates for Pinder, Bourne, & Co.

THOS. ALLEN—modelled majolica vase—Rape of the Sabines, for T. Mortlock, paintings after Boucher.

J. SLATER—paints vases for Minton & Co. Birds, &c.

J. H. WOOD—designs ewers and basins for Pellatt & Co. Milk jugs and déjeûners.

J. Randell—paints birds, fishes, on ewers and basins for J. Rose & Co.

Kerr & Sons—design and exhibit a breakfast service of Belleek ware.

Rouse—painted cattle on Rose du Barry ground for card-tray for Daniell & Son.

J. R. Lees—designed ewers, basins, dessert services for Powell & Bishop.

J. Ellis—executed the preceding designs of Lees.

Williams & Davis—designed "View of Whitley Court" for a Tazza of Worcester Works.

V. Perling—painted dessert services for Royal Worcester Works.

Miss Margaret Tupper—original designs for tiles, card-plates, cups and saucers.

C. Palmere—painted two déjeûner services for R. P. Daniell, one à la pompadour, in turquoise and gold, 1871; the other, "Views of Mentmore," Blue de roi and raised gold, from designs by C. J. Rowe.

Mr. & Mrs. Steele and D. Lucas—design dessert centre-pieces for Thomas Barlow.

J. Booth and J. Bate—painted roses and pearls on a coffee set, and "the Lorne" for a card-tray.

E. Bejot—designs and decorates in the Persian style and in Henri II. ware.

Roberts, Hill, J. Callowhill, J. Williams—landscape; J. Bradley, spill vases.

Davies, Webster—flower holders; Clarke, jardinieres; Bolt, J. Hopwich, spill vases.

E. Stephan—spill vases; all the preceding eleven paint on porcelain for the Worcester Works.

W. Cooke—painted cups and saucers for R. P. Daniell.

J. S. Whitty—painted porcelain views of Highgate, Harrow, &c.

Kuhn figures and Gorner flowers—painted on porcelain for Royal Berlin Works.

Mitchell—painted cattle for Minton & Co.

J. B. Fidler—decorates Graffito ware for Maw & Co.

Baron Davillier—copies Henry II. ware for Theod. Deck of Paris.

H. S. Marks, A.R.A.—painted a Falconer on hexagonal tesseræ.

R. Monti, J. Hadley, W. Theed, L. A. Malempre, M. Noble, R. A., T. Wolner, M. C. Belleuse, J. Durham, Westmacott, Papworth, T. Brock, E. M. Miller, Miss S. Terry, P. MacDowell, Professor Molin of Sweden; the preceding fifteen model ceramic statuary.

J. Gibson, R. A.—ceramic statuary, "Nymph at Bath."

F. Fuller—of Florence, modelled "Nydia," of Parian gilt, for Minton & Co.

F. Mantel—modelled bust of Bismarck, and vases.

Walger—modelled bust of Count Moltke, in white biscuit, for Royal Berlin Works.

Professor Scholander—designs earthen-ware vases for Rostrands & Co.

Pienne—models and decorates Faience à la Henri II., for Royal Worcester Works.

H. Protat—models in the Chinese style for Minton & Co.

J. Janda, Itzenplitz, Flancock, Wilmore—model ceramic statuettes.

G. J. Cox, H. Hohle, C. Luckhardt, C. Schmidt, Simpson —paint placques.

Godfrey Sykes—modelled an excellent column for Theatre of S. Kensington Museum, and designed art tiles for Simpson & Co.

EARTHEN-WARE.

Earthen-ware possesses a hard, opaque, partly refractory body, covered with a transparent glaze, and withstands certain alterations of temperature.

It is composed of plastic fire-clay with an addition of fine ground quartz or refractory stone, and occasionally of lime. Thus in England 83 parts of Dorsetshire clay (containing 76 silica to 24 alumina) are mixed with 17 of ground flint. The ware is brought to the state of biscuit by one firing, at 60°

to 100° Wedgwood, before the glaze is applied (see Stoneware Ovens).

The glaze is a colorless transparent glass of variable composition, white lead being the base. Borax is used to heighten the lustre of the colors. Silica and alumina (derived from kaolin and Cornish stone), flint, felspar, alkalies, saltpetre, and chalk are variously used. To obviate a yellowish tinge, less than one thousandth of smalt is added, producing a bluish hue. The glaze is first burnt (for instance in Bosch's oven) to a glass, the oxide being added before or after the burning; this glass is ground very fine, tempered with water, and the ware in the biscuit state is dipped in it, and then burnt a second time at a lower heat of 12° to 30 W. to fasten the glaze. The glaze should be hard enough not to be easily scratched by the knife.

When patterns are printed on the ware, they are applied before the glaze.

Cowper gives the following glaze:

Silica	43.66
Alumina and Iron Oxide	9.56
Borax	20.08
Carbonate of Lead	15.19
Chalk	10.88
Calcium	0.52

to form which, Cornish stone, granite, borax and gypsum are used.

For superior qualities of earthen-ware 16 to 26 per cent. kaolin is added to whiten the body, and a small quantity of Cornish stone (1 to 3 per cent.) to render it denser. This forms the basis of cream-color.

Part of the Dorsetshire clay is frequently replaced by the Devon, which is somewhat inferior.

The ground flint is added to whiten the body, and to diminish the great plasticity of the Dorset and Devon clays to a point more suitable for working.

The German Feines Steingut and the French fine Faience correspond to English earthen-ware; they are as white and glossy, but less dense and resisting.

For further details, see Tiles and Majolica.

Lead Glazes.—Oxide of lead increases the fusibility, adhesion, and elasticity of a glaze, but makes it easier to scratch with the knife, and somewhat yellow. When the glaze contains free lead oxide not saturated with silica, or when the ware is not enough burned, it is deleterious for fire crockery. To detect this, drop vinegar on the ware, after a while insert a piece of clean granulated zinc, and there will be a grey deposit of lead. Before using such crockery, wash it out with hot strong vinegar.

To make sanitary ware, free from lead, is not easy without increasing the cost. A boracic glaze may be used, or as in Berlin the gesundheitsgeschirr, the body glaze, given by Kerl, viz.:

Body—	Kaolin	48	Glaze—	Sand	42
	Pipe clay	37.5		Kaolin	33
	Felspar	16.5		Raw Gypsum	13
				Ground Porcelain	12

COLORS FOR ALL KINDS OF POTTERY.

The color of an object is due to its action upon the light falling on it.

When white light strikes an object, a fraction of the light is reflected from the surface, without alteration of its whiteness; the remainder penetrates the surface and is decomposed, at an exceedingly small depth, into colored rays; part of the colored rays are absorbed into the body; the remainder are reflected, and it is these which we see, and whose color we consider to be the color of the object. Hence the influence which the state of the surface of a body has upon its colors.

This property of selecting certain colored rays, and rejecting others, is possessed by metallic oxides in an eminent degree. When these oxides are disseminated through a white mass, they impart their color to the mass. Some oxides, and they are the most valuable, are stable in the presence of other bodies and of high heat; the colors they impart do not alter.

Owing to these qualities, metallic oxides are commonly used, as coloring agents.

Bodies are transparent, when the light spoken of above as entering the body, traverses it, and is transmitted beyond.

Bodies are opaque, when the light which enters is quenched by the numberless successive reflections it undergoes at the surfaces of the particles of the body, and does not pass beyond.

By disturbing the perfect contact of the particles, a transparent body is rendered opaque. Example: plate glass and glass ground fine.

By restoring the perfect contact of the particles, by filling the interstices with a transparent substance, the transparency is restored, more or less. Example: paper and paper oiled.

Partial transparency is likewise obtained, by filling the interstices with a vitreous flux. Example: porcelain.

The following colors are obtained with the oxides (and sometimes salts) of the metals named.

Violet—Iron, manganese with soda.

Purple—Chloride of gold with tin, chloride of silver.

Black—Iron, manganese, uranium, iridium.

Indigo—Of violet and blue.

Blue—Cobalt, carbonate of cobalt, smalt or silicate of cobalt. Zinc brightens blue colors.

Turquoise—Copper with soda; cobalt with zinc and soda phosphate.

Green—Copper, with or without antimony; chrome with cobalt.

Bronze green—Nickel. Zinc and its carbonate brightens all greens.

Olive green—Nickel with cobalt.

Yellow—Antimony, with potash or sulphide, titanium, chromate of lead, chromate of barytes. Zinc brightens yellow.

Buff—The preceding with iron, sepia, sienna, ochre, umber, earths.

Orange—Uranium; sulphide of antimony with iron.

Red—Iron, iron sulphate, copper (oxidule), ochre.

Carmine—Chloride of silver.

Pink—Iron and chrome with potash.

Brown—Iron, chromate of iron, manganese, with or without cobalt, ochre and hammercinder.

Grey—Iron, cobalt, iridium, platinum, titanium.

White—White clay and 5 per cent. tin oxide.

In pottery, the colors are either (encaustic) incorporated in the body, or applied upon the surface of the body, which has been previously dried, half burned or fired to receive them, or introduced in the glaze, or applied over the glaze.

Encaustic Colors.—Encaustic colors possess all the more brilliancy, the nearer the body approaches vitrification. The coloring oxides are introduced in quantities usually of 5 to 10 per cent., and sometimes 15 to 20 per cent. They act as fluxes and increase the fusibility of the mass. The composition of the body must be altered in some cases to counteract this.

When the body is fired at a temperature too low to develop the required color, or when it is not of a sufficiently vitreous nature, the color is fritted before being introduced, *i. e.*, the coloring oxide, by the addition, for instance, of 18 per cent. calcined soda and 75 per cent. silica, is melted up into a glass. This glass is ground fine and mixed with the body in various proportions of $\frac{1}{6}$ to $\frac{1}{3}$ and $\frac{2}{3}$ (see Jasper Ware).

This colored body may be glazed, or first painted upon in the new opaque enamel colors and then glazed. Transparent colors cannot be used to advantage upon it.

Colors under the Glaze.—The process consists in dipping the dried object in a slip of colored clay, formed usually of 1 colored glass ground and 2 of clay. The clay is introduced to procure the adhesion of the slip. The ware is then burnt, or, after drying, coated with a transparent glaze and then burnt. Subjects may be painted under the glaze, with more or less transparent colors, or with opaque enamel colors. Before applying the glaze, all oily substances should be removed by a preliminary heating.

Printing in colors under the glaze, is frequently done.

Colors in the Glaze.—The ware is dipped in a transparent colored glaze.

The glaze is frequently formed, besides the coloring oxides of:

Oxide of lead..........	from 40 to 50	per cent.
Silicious sand.........	" 30 " 40	"
Salt..................	" 0 " 12	(see Earthen-ware).

A mode of decoration consists in reserving certain parts from the colored glaze, by which the color of the body or the slip appears in those parts. This is done by covering the reserved spaces, not with oil, which spreads, but with melted tallow and wax, which solidifies on the spot. The ware is then dipped in the colored glaze, heated to expel the grease, and then dipped in a transparent glaze, which adheres to the reserved spaces.

The application of a colored glaze over a painting is very effective in harmonizing the whole.

By stamping a depressed pattern in the biscuit, and glazing, the pattern will appear in a deeper tone of glaze.

Colors over the Glaze.—The colors are applied with a brush over the (once fired) glaze; the ware is heated again to the melting point of the glaze, which in the melted state incorporates the colors, and appears more or less to cover them. To prepare the colors, one method consists in rubbing the coloring oxides in water, to which gum, or sugar, is added to cause cohesion. Turpentine oil and its fat essence are more often used, also Lavender oil. Only colors which will stand high heat can be thus applied.

In the case of hard porcelain, the colors melt sooner than the glaze, hence their opaque appearance, as the glaze does not cover them. Another method, applicable to all colors, consists in mixing them with substances (silicates, or borax) which when heated will give a vitreous mass, capable of uniting with the glaze or the body of the ware.

The colors thus obtained are transparent. When laid on too thick, they peel off. Colors that are volatile, vegetable and others, can not be used. Color printing can be executed over the glaze.

Metallic Colors.—For gilding there are several methods. The gold is fine, obtained by precipitation, and amalgamated with oxide of mercury or calomel to spread it. Sometimes gold leaf is rubbed in sugar, salt or honey, and applied. If the glaze is earthy, 8 per cent. of flux of oxide of bismuth, with a little borax, must be added to the gold.

Silver is applied in a similar way.

For platinum, the metallic powder is fluxed with 10 per cent. of a boracic flux, and rubbed in oil on a glass plate.

The gilding is applied with a brush over the glaze and requires high heat to fasten it; it must be applied and fired before other colors. The gilding has a dead appearance until it is polished with agate instruments. There are other methods of gilding less permanent.

In Egypt, graphite rubbed on gives a black polish. In India, gray and copper-colored mica, rubbed on the surface, gives a metallic effect.

Lustres.—By coating the ware with a glaze, which furnishes a thin, adhesive, metallic film, the rays of light are decomposed into prismatic colors, producing a pearly, lustrous appearance. (See Belleek Ware.)

The lustre may be transparent, as with the metals lead, zinc, alumina, bismuth, or colored, as with copper, manganese, cobalt, iron, uranium, nickel, cadmium, chrome.

The transparent lustres are obtained by melting 10 metallic oxide or salt with 30 colophonium, and rubbing in 70 to 140 lavender essence. It is applied like a varnish.

The large amount of carbon in lavender essence acts as an effective reducing agent to produce the thin deposit of unoxidized metal in the glaze. The most brilliant effects are obtained by using the transparent with the following lustres:

COPPER LUSTRE—RUBI LUSTRE OF GEORGIO—is considered to be silicate of protoxide of copper. Salvetat says nitrate of copper and a reducing gas will produce it. Or else, for white enamelled ware, throw a paper containing copper oxide into the muffle.

Uranium—mother of pearl lustre.—10 nitrate of uranium, 30 colophonium, 50 lavender essence.

Iron lustre.—Chloride of iron and solution of soda; the deposit is rubbed in lavender essence. The lustre is red. By adding bismuth lustre it becomes golden yellow.

Purple gold or Burgos lustre.—Dissolve in acid 25 gold, 5 tin; mix with 50 sulphur and 20 essence of tar, and 50 essence of turpentine.

Cantharides lustre.—A lead glass, with a little oxide of bismuth and chloride of silver, is applied with the brush.

The ware is fired; when red, it is smoked.

The lustres are brighter when laid over a brilliant glaze.

To reserve certain spaces, wash off the lustre, by dissolving with linseed oil.

Printing in Colors.—To print on the glaze: The design is printed in linseed oil colors on damp silk paper. The paper is dipped in water, taken out, the excess of water absorbed, laid on the ware, which has been previously varnished with turpentine oil and alum or copal, and a woollen roller or ball is passed over it. The ware is then fired.

To print on the biscuit.—The colors are rendered more adhesive by glue. The paper is stronger and dipped in soap-water to prevent absorption of oil. Before laying the paper on the biscuit the parts not colored are cut out. The ware is heated to expel the oil, before glazing.

Gelatine may be substituted to paper; the pattern then is only printed in turpentine and nut oil, and the color in powder is sprinkled on it.

PREPARATION OF COLORING AGENTS.

Chrome oxide—from bichromate of potash calcined.

Iron oxide—from iron sulphate calcined.

Uranium oxide—from a blend by chlorhydric acid and nitrate of iron, used as uranate of ammonia.

Manganese oxide—found as such.

Zinc oxide—from a salt of zinc precipitated by carbonate of soda.

Cobalt oxide—from a cobalt ore, roasted, treated by acids, and precipitated by potash carbonate.

Antimony oxide—heat 2 of antimony and 5 saltpetre; antimoniate of potash results. Also from Naples yellow.

Copper protoxide—from sulphate of copper, soda carbonate, and copper shavings.

Copper peroxide—from nitrate of copper calcined.

Tin oxide—from tin. The alloy of lead and tin oxidizes rapidly.

Iridium oxide—from a solution of iridium, sal ammoniac, potash carbonate.

Chloride of silver—silver nitrate, precipitated in the dark by chlorhydric acid.

Purple gold—At Sèvres, 3 gr. tin is dissolved cold in acid (4 nitric to 1 chlorhydric), and 1 gr. gold in acid. Diluted and slowly mixed. Or else, heat gold protoxide with stannate of potash.

REMARKS.

A remarkable pure blue, says Gentelle, is obtained by taking 2 parts of flux (composed of equal sand and lead oxide) and 1 part of color composed of 16 protoxide of cobalt, and 84 of the following precipitate:

To a solution of soda phosphate in excess, add zinc sulphate; wash the resulting blue precipitate, which contains, when dried, zinc oxide 42, cobalt protoxide 13, phosphoric acid 33, water 12, and burns to a pure blue.

For very white opaque enamels, the mixture of 200 oxides of lead and tin, 100 sand, 80 carbonate of potash, must be melted up and pulverized 3 or 4 times successively. When antimony is substituted for tin, the lead must be left out, or it would produce a yellow tint. This antimony enamel is better for blues and purples than the other. Clouet gives as the best: Glass, without lead, 300; borax, 100; saltpetre, 25; antimonium diaphoreticum, washed, 100.

Colored slips for staining the surface of wares vary with the colors. For common blue and green, some 7 per cent. lead oxide is introduced, while it is left out in others. Thus, for red, ochre is rubbed in water; for violet, 1 sand, 2 potash, $\frac{1}{16}$ manganese, are fritted and mixed with thrice their weight of white clay; for yellow, 1 sand, 2 potash are fritted, and 2 white clay is added.

DECORATIVE TILES FOR FLOORS, WALLS, ETC.

The variety of tiles come under the following commercial classification:

1. Plain Tiles (self-colored) made by pressure from dust clay. With different colored pieces geometrical patterns can be formed.

2. Encaustic (figured) Tiles, having a flat surface with the ornament inlaid, or slipped in various colored liquid clays. These two may have their surface covered with a transparent glaze.

3. Enamelled Tiles, that is, plain tiles having their surface covered with various opaque and transparent colored enamels.

4. Majolica Tiles, having the ornament in relief, the embossed ornament and the ground being covered with various colored enamels. (Palissy ware, more properly speaking.)

5. Earthen-ware Tiles in plain colors, glazed.—These may have their surfaces decorated by printing or painting.

PLAIN TILES.

These tiles, made from colored dust clay by a sort of coining process (see Tile Presses), are capable of being highly decorative when well made, and are a good instance of the pleasure arising from mere perfection of material.

The clay or mixture of clays used is usually reduced to a fine powder and made slightly damp before pressing. (See Encaustic Tiles and Colors.)

ENCAUSTIC TILES.

Encaustic tiles consist of a slab of clay of uniform color, inlaid with a device of other clays differently colored.

In this ware the colors are not superficial, but are incorporated with the body of the clay before burning, either by pugging dry or in the condition of a liquid slip.

As to the different coloring ingredients:—Many of the clays which contain less iron, such as the Stourbridge and others in proximity to the coal measures, do not come out of the fire red like brick, but white, cane or buff in all varieties of tint, and stand the attack of fire and weather.

Red, salmon and pink will be produced as the iron predominates, altered by mixtures of other clays in their native condition or by oxides of metals. Nickel, for instance, produces a bronze-green tint; manganese brown; protoxide of iron and manganese dead black. Carbonaceous matter gives a dark, dull-looking and rather dirty tint, which may be useful in contrast.

There is no end to the variety of tints which can be obtained by the admixture of earths and metallic oxides. (See Colors.)

To economize the inlaid colored clay material, the tile is only formed of it to the depth of about $\frac{1}{4}$ of an inch from the surface, the mass of the tile being made of fire-clay. As, however, the fire-clay generally contracts very differently from the surface layer of colored clays, it is usual to apply to the back of the fire-clay, an equal thickness of about $\frac{1}{4}$ of an inch of the colored clay, in order to preserve the flatness of the tile during the firing. The tile is made with the aid of a press, either by the wet or dry process. (See Tile Presses.) By pressing many small holes in the back of the tile, the drying is facilitated, and also the adhesion of the mortar when subsequently used on the wall. The tiles are dried for a week, then heated in a drying oven for two or three weeks, fired in a stone-ware oven for sixty hours, and left in the oven for six days more to cool down. The lineal contraction during these operations amounts, in the wet process, to twenty-nine per cent. of the size of the tile when first moulded. It is less in the dry process.

For glazes, see Earthen-ware and Colors.

ENAMELLED TILES.

The bodies are the same as for plain tiles, which have at most a transparent glaze, while the enamelled tiles are susceptible of great variety of decoration, by the application of transparent or opaque colored enamels.

By reserving spaces (by oiling or otherwise) and dipping the tile in a slip, or by direct application of the enamels, simple and effective results are obtained.

For the enamels used see Majolica.

MAJOLICA AND MAJOLICA TILES.

The different varieties of Majolica are more easily appreciated when its history is recalled.

The almost total extinction of the arts and sciences which followed the fall of the Roman Empire, left Europe with only the rudest knowledge of the potter's art. The Moors brought with them into Spain, in the eighth century, much of the science and knowledge of the East; but it took several centuries for the arts thus introduced to spread over other parts of Europe. The enamelled bricks and tiles of the Moors were of superior taste and coloring, gilding was skilfully used, and the enamel possessed a yellowish lustre of peculiar brilliancy. Their bricks (azulejos), as in the Alhambra, were formed of a light-colored clay, covered with an opaque white glaze upon which Eastern patterns were traced in colors. This manufacture was continued and is still kept up in Spain.

In Italy, the art of Pottery, which attained its height during the fifteenth and sixteenth centuries, was introduced in the ninth century by the Moors of Spain and also by Byzantine Greeks. In 1115, an expedition, fitted out from Pisa, conquered the island of Majorca, and brought back as spoils the bricks and tiles of the Moors, thenceforward called Majolica.

The earliest known specimens of Italian majolica presented an arabesque pattern painted in yellow and green upon a blue ground and possessed a yellowish chromatic glaze. The red clay, which formed the body of the ware, was moulded and burnt, then dipped in a white opaque enamel, consisting in oxide of lead, oxide of tin, and a very white earth from Sienna. When dry, the pattern was painted on it, then washed over with a thin lead glaze and burnt a second time.

From 1450 to 1530 the product is distinguished as mezza-majolica. The outline of the figures were traced in blue upon a black or white ground, and the draperies faintly colored; there were no shadows and the flesh parts were not colored, and the whole was covered with a chromatic mother-of-pearl like glaze which imparted a golden and silvery lustre to its yellows and whites. Under the house of Urbino, the manufacture of mezza-majolica flourished at Pesaro and at Gubbio, where its chief artist, Georgio Andreoli, first applied a transparent ruby-colored lustre, which, with the previous golden and silvery tint, produced a lustre like burnished copper, and particularly brilliant over a blue ground.

At the beginning of this period, the sculptor Luca della Robbia (born 1400, died 1481), after many trials, discovered that by increasing the proportion of oxide of tin in the glaze, a hard opaque brilliant pure white enamel was produced, which he applied upon terra-cotta statues of Madonnas and saints, and architectural ornaments, and abandoned the previous chromatic characteristics of the ware. His principal decorations were in white, over a blue ground. Several years after his death, this glaze came into general use at Faenza, and at Florence, whence the name of faience, which is now applied to earthen-ware covered with a white enamel.

From 1530 to 1560, the artistic character of majolica attained its highest point, and designs of Raphael and his scholars were frequently used. After 1560, its utility had been so far sacrificed to decoration, that it rapidly died out upon the introduction of porcelain.

The manufacture of majolica was carried into Germany by Hirschvogel, who went, in 1503, to Urbino to learn the art, and on his return, erected a manufactory at Nurnberg; but Germany possessed enamelled earthen-ware factories before then, and in Holland the potteries of Delft were already celebrated.

The manufacture of faience passed into France with Catherine de Medicis, and the Duke of Gonzago erected, in 1570, a majolica manufactory at Nevers, which was so successful that its products are hardly to be distinguished from the original majolica. Considerably prior to this, however, the potteries of Beauvais were already known in the 12th century; and in 1555, Bernard de Palissy had discovered for himself the art of enamelling a gray paste. The originality of his decorations, and the skill and humor shown in the modelling, give particular value to his majolica; but his art, which he kept secret, disappeared with him, until its re-introduction from Italy in 1570. The French Henry II. ware also preceded the introduction of faience into France.

In England, delft ware and colored enamelled tiles from Holland were already imported at the time of Henry IV. The modern revival of majolica there, is due mainly to the labors of Mr. Herbert Minton. In imitating the azulejos of the Alhambra, he was very successful. The tiles of earthenware are burnt, then covered with an opaque white tinny glaze, upon which the outlines of the decorations are distinctly traced, and filled in with a thin coat of enamel of various colors, and again burnt. Aniline colors may be used to imitate enamel.

The Palissy ware, formed of embossed biscuit covered with transparent glazes of various colors, is frequently called majolica, although this term should properly be reserved for biscuit (*i. e.*, burnt earthen-ware) coated with an opaque enamel.

The majolica of Messrs. Minton & Co. differs in many respects from the modern Italian, French, and Dutch varieties, as well as from the old majolica. The continental ware is formed of limey clays, consisting for white faience of 58 silica, 35 alumina, 7 carbonate of lime; and for brown faience, of 57 silica, 38 alumina, 5 carbonate of lime.

The lime solidifies the body, makes it more liable to crack over the fire, but facilitates the adhesion of the enamel, by partly melting with it and imparting to it a fat, glossy appearance. Other faiences and old majolicas contain (Pichenot, etc.) 13 to 22 per cent. of lime, and 1 to 14 per cent. of carbonic acid, the temperature required to fire the biscuit not being sufficient to expel all the carbonic acid. (Palissy ware contains only 1.5 lime.) The silica and alumina are usually in the proportion of 2.5 or 3 to 1.

In England, the fire-clays used come from the coal formation, contain no lime, are fired at a higher temperature, and produce a denser, harder biscuit, generally of a buff color, but the enamel is less glossy. Its greater power of resisting fire allows of its embellishment with several colors, such as turquoise blue, Chinese yellow, and crimson, requiring great heat for their development. The colors and glazes of Messrs. Minton are of remarkable excellence. Others excel in artistic designs.

Knausz gives the following opaque white enamel:

Oxide of lead	23.6
Oxide of tin	15.6
Silica	43.5
Alumina	1.7
Oxide of iron	0.5
Lime	3.8
Magnesia	1.6
Alkalies	10.0

The enamel may be fritted, *i. e.*, fired once to a melting heat (about 70° W.) and ground fine. A sudden immersion in water while hot facilitates the grinding and heightens the lustre. Part or all of the coloring metallic oxides can be added after this firing.

The relative proportions of oxide of lead and oxide of tin vary. An increase of the lead gives a thinner, more transparent, fusible, and brilliant enamel, which sinks too much into the ware under high heat. An increase of the tin gives a whiter, harder, thicker, and less fusible enamel, of greater covering power. Frequently there is 2 to 4 times as much lead as tin. In white enamel these oxides constitute together 39 to 48 per cent. of the enamel; the remainder consists of 43 to 47 silica, with 3 to 8 common salt, and 2 to 3 of soda. Sometimes a trace of lime.

When required to stand a high heat, the silica should be of the cleanest quartz sand.

In Germany the mixture of oxide is obtained by melting 100 lead with 50 sheet tin, in contact with the atmosphere.

For colored opaque enamels 90 to 97 per cent. of the white enamel is mixed with 10 to 3 per cent. of coloring metallic oxides.

Stanniferous enamels have sometimes, after a lapse of time, a tendency to peel off, owing to want of affinity of the silicates of lead and tin for the body of the earthen-ware. The melting point of the enamel should correspond to an incipient softening of the body, when, by a tendency to absorption, it will adhere to the ware. If the enamel is too fusible, it will be too thoroughly absorbed by the ware, and lose its lustre. If wanting in affinity, it will collect in separate drops on the surface, which fall off later.

The expansion and contraction of the enamel must approximate closely to that of the body, or numerous cracks will result. These occur also when the glaze is too thick.

If the enamel is too refractory, it will be defaced by cavities and points showing only a partial fusion.

Phosphate of lime can be introduced as a whitening, and, until fluxed, infusible ingredient. Majolica tiles are better for walls, and not so good as encaustic tiles for floors.

EARTHEN-WARE TILES IN PLAIN COLORS, GLAZED.

They may have their surfaces decorated by printing or painting. By dipping the earthen-ware tile in a slip of white or colored clay (see Colors under the Glaze) a smoother and differently colored surface is obtained for the decoration.

The transparent glaze is colorless or diversely colored (see Colors in the Glaze). It should not be crazed. Also, spaces may be reserved from the slip or the glazes. The Persian patterns of Minton & Co., on a Persian body or slip, for wall tiles, are admired for transparency and the turquoise blue.

DESIGNS FOR TILES.

It is generally admitted that flat treatment is the most appropriate for floor designs. Startling contrasts of form or color, which attract our attention to the exclusion of almost everything else in the apartment, fail to produce a harmonious effect. Rich and full colors can be so combined as to produce a quiet and unobtrusive pattern.

Any design presenting the appearance of inequality of surface is more objectionable in tiled floors than in carpets even, from the greater rigidity and hardness of the material. Pictorial imitation seems a waste when destined to be trodden upon. The best result is perhaps observable when a pattern upon a ground of a simple color, or of non-contrasting colors, is used to give repose. The combination of many colors in one pattern is, of course, attended with much greater difficulties than the use of a few, as among all the possible combinations, the concords are much fewer than the discords, and not likely to be hit upon except by careful study. The pleasing effect of Oriental patterns is instructive in this respect. Success seems more easily attained when the patterns are distinctly grouped and ornamental borders added.

The richness of the material should not be concealed by profuse surface coloring, but rather brought out by distinct encaustic colors.

"The attempt to make each tile a decorative unit, and to multiply it over the whole floor, is rarely satisfactory. Forms of this kind occurring over large spaces are likely to prove very tedious to the eye....... The decoration of the floor must depend upon the use of the apartment. Large and somewhat empty entrance halls call for more pronounced treatments; aspect and use also must determine whether the floor should be cool or warm in its coloring."—(*Redgrave.*) For wall tiles, breadth and quiet are more desirable even than for floors. A design producing diagonal lines, or horizontal lines, is not as good as vertical lines.

Messrs. Minton's Persian designs and Maw & Co's Rosette patterns are particularly admired.

TESSERÆ.—MOSAIC BRICKS.

Tesseræ or blocks for mosaic brick are made by a machine exhibited by M. Hollins & Co. The small squares are made by this process in a dry condition. Formerly the clay was wet when shaped, which caused many of them to warp, as they dried before baking. They are now formed of dry-powdered clay, stamped together with great force in small moulds, so that the particles adhere together.

Minton & Co's stamping press for producing mosaic bricks, makes slabs from 1½ inches square, used for flooring tiles, down to the minute pieces used for delicate mosaics. It is a vertical screw press; dies of the required shape pass through openings in a circular metal table, into matrices below. The clay finely pulverized and colored by different pigments, as desired, is heaped upon the table, and a small portion is swept into the matrices by hand at each downward stroke of the press. The cubes are arranged and dusted, and then baked. The heat vitrifies them, and they appear with an opaque glazed surface. Various pigments are adedd to the clay. The picture is made by reversing the tesseræ and gumming them on a board; the back is then covered with a cement composition, and the board taken away from the face.

The clay is not that used at the Potter's wheel, nor the same as is used for fine china. It is "Cornwall clay," a white substance obtained along the edge of a granite formation, where the rock has been oxidized and disintegrated for ages by the atmosphere. The thickest veins are to be measured in inches. When this disintegrated granite has been obtained, the particles of mica and other impurities are washed away, and the residue of converted quartz is "Cornwall clay." (For fine china, there is in England an addition of bone dust and other ingredients.) This clay, when baked without the addition of coloring ingredients, forms pure white earthen-ware, of which material the tesseræ are made.

TERRA-COTTA.

Terra-cotta in its application to architecture still has its advocates and opponents. When properly manufactured it is one of the most durable materials which can be employed; but, like stone or any building material, it requires inspection before use.

Very fine specimens of terra-cotta made in London one hundred years ago, and exposed to the weather since, are still perfect. In Northern Italy many fine examples of brick and terra-cotta exist, and the extensive revival in England and Germany of this method of building, is worthy of note.

The strength of well made terra-cotta is surprising. A piece of four-inch column, made by Jas. Pulham, and tested at the 1851 Exhibition, required a pressure of 400 tons to the square foot to crush it, or as much as good granite, and two to three times as much as most building stone. In a paper recently read at the Architectural Conference in London, Mr. C. Barry gave some valuable results of experiments on terra-cotta, showing the crushing strength of this material to be seven and a half times greater than that of average brick.

The difficulty of obtaining a really durable building stone, is well known to architects, and practical experience is required in its selection; architects do not agree, some preferring limestones to sandstones, others sandstones, nor is it settled which are the best beds. Stone varies much in every quarry; an instance in point is the Geological Museum in London and the Houses of Parliament, both of the same magnesian limestone; the first lasts well so far, but the latter is rapidly decaying, and many protecting coats have been tried upon it, to arrest decay.

The test of the amount of water absorbed, is conclusive neither for terra-cotta nor for stone, as some materials absorb more water, and yet withstand frost better than others, owing to their great cohesive strength.

The quality of a stone is so difficult to discover, that the most durable stones are not unfrequently rejected. Even granites are not all durable, particularly those with a soapy fracture, which, by weathering, decompose, and furnish the china and pipe-clays so extensively used in the industries. The difficulty of finding a material that will stand heavy frosts is seen in St. Petersburg; the Alexander Column, a granite monolith 84 feet high, is split in several places from this cause, and in the public monuments some of the largest granite blocks are rent in two.

In erecting large buildings it is difficult to supply quickly enough stone of a durable quality from one quarry. Nearly all stone is not fire-proof, but cracks when exposed to high heat.

These causes, without deprecating the use of stone, point to the desirability of finding a durable fire-proof building material, which can be relied on always and supplied in large quantities. This presents an opening for the use of terra-cotta—a material which has stood the crucial test of firing.

A simple test of the texture of terra-cotta is the point of a pen-knife, which should not penetrate the surface, and will sometimes strike fire upon it. A clear and bell-like ring is also an evidence of homogeneity and compactness, and a clean close fracture shows strength. The texture of the body and the precision of the forms are further indications of accurate firing and homogeneous material.

The true qualities of terra-cotta in its application to architecture consist in its merits as a decorative fire-proof material, possessing the three essentials of color, durability, and economy.

When treated with due regard to construction, so as to fulfil its part in the building as honestly as the brickwork of the wall itself, the high capacities of the material to receive artistic treatment admit of the impress of original art being reproduced for the uses of the architect, in an almost imperishable substance.

Fine works in hard stone are exceedingly difficult of execution, and in soft stone soon crumble away; the labor of the artist may be saved by taking a mould of his work, and reproducing it in terra-cotta as often as may be required; indeed, the great economy in the use of terra-cotta lies in producing a great number of articles of the same pattern.

Where original art is required, the subject can be modelled in the actual terra-cotta clay, and passed through the kiln, from which it issues an original work of the sculptor, without the intervention of mechanical copying, moulding, pointing, or carving.

Modern examples of the extensive use of terra-cotta are seen in the Dulwich School, (from designs by C. Barry, Jr.), costing $500,000, and accommodating 700 boys; the Kensington and other Museums; various hotels and stores, and the great Albert Hall, which cost one million dollars. This building is of brick and terra-cotta, contains seats for 8,000 persons, and is capable of accommodating 16,000 without discomfort. The same structures, decorated in stone, would have cost much more.

An example of successful decoration is the permanent brick and terra-cotta arcading at the International Exhibition. In the successful use of these materials, the architect, Col. Scott, deserves praise.

TERRA-COTTA MATERIALS.

Terra-cotta, or literally "burnt clay," would seem from its name to be very simple in its manufacture; yet to produce a material as strong, more durable, and less expensive than stone, requires an exact scientific knowledge of the properties of many varieties of clay, and accurate observations upon their behavior in the oven.

The improvements visible in many species of ceramic production, may be attributed to the increasing regard paid to the chemistry of the manufacture and the physical phenomena involved. In the same way, success in terra-cotta is in proportion to the exact experimental knowledge possessed of the natural properties of the various clays; for there is no such thing as a terra-cotta clay, ready for use under conditions that are always applicable. By judiciously selecting and combining different clays, the best results are obtained. We will, therefore, review the natural materials which the manufacturer of terra-cotta has to choose from.

Pure clay—the hydrous silicate of alumina of chemists—is absolutely infusible in the greatest heat to which we can subject it. But pure clay is rarely found in nature; it is usually combined with other substances.

The common clays consist of silicate of alumina in coarse admixture with sand, lime, iron, carbon, alkalies, and not unfrequently much organic matter. The variety found in the composition of common clay is not surprising, when we examine its origin, and see that it results from the decomposition of felspathic rocks and soils by weather and water, and is found lining the banks of rivers and the bottom of valleys and seas. Nearly all the common clays contain much lime and iron, and are fusible at an ordinary furnace heat. The better varieties are soft to the touch, but want unctuosity.

Some of these clays are adapted to brick-making; they are the brick clays, and consist of silicate of alumina with admixture of silica sand, which is essential, and may even reach a proportion of 90 per cent. of silica, and still form excellent brick. Silica in the mealy state is injurious to clay intended for brick-making (excepting Bath brick). Also, any considerable quantity of lime, iron, potash or soda, is unfavorable, and in a good brick clay there should not be more than two per cent. of lime or potash, for these substances cause the brick to run into glass when in the kiln.

Fire-clay is a variety that will bear intense heat without melting in the kiln or in furnaces. The fewer different elements it contains the more infusible it generally is, following in this respect the rule applicable to metallic alloys, which are fusible in proportion to the greater number of different elements they contain. This rule, which is not absolute, also accounts for the melting qualities of fluxes in general, and is applicable to common clays.

The alkaline earths, iron oxide, etc., which would help to form a flux, are therefore absent in fire-clays. Many excellent varieties of fire-clays are found in the coal measures, and they usually result from the decomposition of the older rocks, exposed at the time of the coal period. They often contain carbon and hydrocarbons.

Pottery clays are more compact, unctuous, and plastic than brick clays; they are very tenacious and ductile, and form with water a semi-translucent mass. When pure they are practically infusible and burn white. They contract much in burning, as they part with their water only under exposure to the furnace. The more oxide of iron they contain the deeper is their red color after burning, and the more fusible they are. They contain ten to twenty per cent. of water, and very little lime or magnesia, while the remainder is silica and alumina, in proportions varying from two to one, to equal parts. Pottery clays seem to result from a natural separation of the objectionable parts of common clay, by the action of water and long exposure to the weather, and are found in deposits.

Pipe clay is a variety of potter's clay, containing very little iron, and, like china clay, is formed from the decomposed felspar of certain granite rocks, either by natural or artificial washing.

In terra-cotta manufacture, one of the most important clays is the potter's clay from North Devon and Dorsetshire (see Fire-Clay Analysis); the neighborhood of Poole supplies the great Staffordshire potteries, the "stone-ware" potteries of all parts of England, and even the Continent. These clays contain a small percentage of alkalies.

Also the clays of the coal measures, technically known as "fire-clays," are greatly employed.

In the terra-cotta manufactures of the North of England and Scotland, the purest lumps of fire-clay are selected by their color and texture, and used alone without any other clay, while the firms near London prepare more carefully a mixture of clays, which produces a body of better texture.

The precise mixture of clays used varies with the appearance aimed at for the terra-cotta, and in this respect manufacturers appear to seek different results. Some try to obtain the texture and pale straw-color of stone; others a red brick color; others again a warmer buff tint.

There seems to be in every case advantage in using a mixture of clays, as a more compact, homogeneous, and better vitrified body is obtained, although at the cost of extra labor and care. One of the chief difficulties met in manufacturing terra-cotta figures and ornamental works is the contraction the clay suffers after it has left the mould—first, in drying, and still more in the subsequent process of firing. By mixing the clays, a further advantage is gained in the diminished shrinkage, as fire-clay terra-cotta (*i. e.*, unmixed) shrinks in lineal dimensions about 12 per cent from the time it leaves the mould until it leaves the kiln; the mixed clay terra-cotta shrinks 6 per cent or less, and red clays shrink 3 per cent.

To enhance the durability of the body of terra-cotta a partial vitrification of the mass is aimed at, by adding clays which, like the Dorset, contain a small amount of alkalies, which act as a flux to fuse the body harder.

Also vitrifying ingredients, pure white river sand, old fire-brick ground fine, previously burned clay, called "grog," are added in various proportions, amounting even to twenty-five per cent. They counteract excessive shrinkage, act as vitrifying elements, and keep the color lighter.

The efflorescence of the alkaline salts in the clays, acting on the silicates of the surface, tend to vitrify more particularly the exterior of the block, and to form a harder surface, which should be left intact.

MANUFACTURE.

The mixture of clays is ground under an edge runner to the consistency of flour. The mills have either revolving or stationary pans; the former do the most work.

In order thoroughly to mix and incorporate the different clays, a subsequent careful pugging is required, for which hot water is sometimes used.

The mixture, when brought to the proper homogeneous consistency, is placed in a plaster mould, withdrawn, dried near the kilns, or otherwise, and baked in a kiln for 5 to 7 days, during which time it is slowly brought to a white heat, and as gradually cooled down again.

There are several varieties of kilns, such as the Hoffman kiln, which serve for terra-cotta and stone-ware. They are improvements only to the extent which they economize fuel, disseminate the heat uniformly, and allow of its perfect gradation to any desired degree.

In order to avoid twisting and warping during the firing, it is necessary, besides complete mixing of clays, that the mould be shaped so as to give a uniform thickness of material throughout, and if the temperature of the kiln be well graded, the homogeneous body will not warp.

To cheapen terra-cotta building blocks, they are made hollow, and filled, during the construction, with concrete or cement.

Although in the kilns the products of combustion are separated from the wares, it is found that the use of sulphurous fuel darkens and tarnishes the surface, and it is to be avoide

DESIGNS.

In treating the clay material, several fundamental principles may serve as guides.

In the design of an object, construction has the first claim upon our attention, and utility has precedence of decoration. This requires a study of the strength of materials, and where it has been neglected, as in some of the architectural pottery exhibited, the result is a prevailing sense of weakness.

The general form of a piece having been determined on sound constructive principles, its details remain to be completed, in a manner that will make the object ornamental in the position it is destined to occupy. It is essential that the ornament should harmonize with the purpose of the object. This part of the design requires an artist for its execution; the schools of design throughout England, of which there are 110, have been largely used to procure these designs, by premiums offered and competitions.

In the representation of objects taken from nature, it is an error, for decorative purposes, to attempt an exact imitation of the natural object; the forms should be conventionalized and adapted to the material dealt with, in a way to bring out fully its true nature and qualities.

The rule of not attempting to conceal the true material, arises from the pleasure which mere merit of material affords, and from the general unsatisfactory effect of all attempts at imitation.

The imitation of stone in terra-cotta is an error for which manufacturers are less responsible than the buyers who require it; but the majority have happily avoided this extreme. When the pale straw stone color is produced by the addition of ingredients whose object is to increase the vitrification of the body, it is perfectly legitimate.

The rich buff color of terra-cotta is usually considered the most pleasing; it requires twenty-four hours longer firing. Although more difficult to obtain uniformity in tint, when produced it is good evidence of hard firing and homogeneous material.

REPRODUCTIONS.

One of the advantages of terra-cotta is the facility with which it lends itself to the reproduction at home of features of architectural merit, wherever found in distant countries. By taking on the spot a plaster cast of a detail of cornice, bracket, column, or other object, and sending this cast from abroad, it may be used for the reproduction of as many similar objects in terra-cotta as the architect requires for a new building.

A practical difficulty is met in taking many casts from one plaster cast, as it requires some skill, and deteriorates the model. This difficulty is overcome by the process of gelatine moulding, as follows:

The plaster model is coated with oil and soap, to prevent adhesion, and covered with a canvas for protection. Rolls of modelling clay are then laid on over the canvas, until the whole surface is covered to a suitable thickness, say 4 to 6 inches; and against this a plaster coating or wall is built up, in, say, two parts, to form a backing for the mould. The two parts are then opened, the canvas and clay are taken out and thrown away, the two parts are replaced, and a hollow interval of the thickness of the clay will exist, into which hot liquid gelatine is poured. After twelve hours, the gelatine will have attained a semi-solid elastic consistency, which will allow of the mould being opened, and the gelatine impression peeled from the face of the model. The gelatine impression is replaced on the plaster wall which previously supported it, and a plaster cast is taken from it. From the latter, about four terra-cotta reproductions can be made without sensible deterioration.

The advantage of gelatine is that it re-produces minutely without deterioration every mark of the plaster model; its elastic nature makes it especially useful for "undercut" carving, as it yields while being released from the cut, and immediately again resumes its shape with perfect accuracy. The process as now used, for instance, for the reproduction of 64 brackets of the New Museum, Kensington, works admirably.

USES OF TERRA-COTTA.

This material finds a ready application to architectural decoration, especially in connection with brickwork. It is used for:

String Courses, Cornices, Vertical Separations, Terminals for walls, Window Heads, Window Mullion Tracery, Keystones, Wall Copings, Pier Caps, Capitals and Bases of Columns, either in connection with marble or granite columns, or of terra-cotta columns plain or twisted, Friezes, Bas Relievos, Figures and Busts, Medallions for insertion in walls Festoons, Chimney Pots and Chimney Shafts, Ventilators and Ridges.

Ornamental and Plain Facing Tiles and Building Blocks, from 1 to 4½ in. thick, formed into Quatrefoil and other Panels, Chequered and Vermiculated Rustics, and Diaper Work.

Fire-proof Ornamental Stair Cases with Newels and Balustrades, perforated or plain Risers, and inlaid with Majolica and other Tiles. The strength of terra-cotta gives it particular value for this purpose.

Garden Decorations of all kinds, Fountains, Basins, Balustrades, Bridges, Tazzæ, Vases, Pendant Flower Baskets, Ferndelabras, Garden Steps, Statuettes, Garden Edging (fixed so as not to get displaced by digging), made also with Encaustic Tile Panels, Horticultural appliances, and Window Flower Enclosures.

Ornamental Conservatories, Lodges, Summer Houses, Aviaries and Dairies.

Mural and other Monuments.

(See list of Exhibitors.)

STONE-WARE.

In the fifteenth and sixteenth centuries, stone-ware, characterized by its dense, opaque, vitreous fracture and impermeable and refractory nature, was already abundantly manufactured in Germany and Holland, whence the industry was imported into England, and encouraged there by Queen Elizabeth.

The materials made use of in England are the refractory white and greyish plastic pipe clays of Devon and Dorsetshire (see Fire-Clays), which are used, alone or mixed, for small articles. For larger objects, white river sand, ground fire-bricks and flint are added to counteract shrinkage and warping.

Salvetat's analysis of stone-ware shows a composition of:

Silica...............	from	62	to	75	per cent.
Alumina	"	19	"	29	"
Iron oxide..........	"	1	"	8.5	"
Lime	"	0.25	"	1.0	"
Magnesia...........	"	0	"	0.9	"
Alkalies.............	"	0.5	"	1.5	"

The shaping of large masses, such as tanks to hold several hundred gallons, takes place on the potter's wheel. A difficulty arises from the length of time (some ten days) required to build up a tank, in the unequal drying of the parts first formed. This is counteracted by wet cloths wrapped around them. While drying subsequently for ten days, it is protected against unequal currents of air. More intricate forms are made in plaster moulds.

The heat required is greater than for terra-cotta, above the melting point of silver, and is one of the highest required for any kind of pottery (100° to 120° Wedgwood). The texture of the body produced is more vitreous and dense. The manufacture of terra-cotta and stone-ware are advantageously carried on together, as the refuse materials from the one can be used in the other, and the less heated story of stone-ware kilns, used for terra-cotta.

The consumption of fuel is a heavy item and depends largely on the kiln. In some, the Siemens regenerator is applied.

In Germany, Bosch's oven is considered economical. The flame enters through apertures at the sides and centre of the floor, is reverberated, descends through other openings in the floor, and reascends through upright flues at the circumference, to a central conical chimney. The objects remain about ten days in the oven, in some cases three weeks. Bonnet recommends the following refractory concrete for introduction in oven walls as a separating lining to retain heat: "Mix $2\frac{1}{2}$ parts clay, $1\frac{1}{2}$ river sand and pebbles, 1 unslacked fat lime in powder; water slightly and ram well."

The ware is usually glazed, although its imperviousness does not require it, for better protection and smooth appearance. The glaze is either a salt glaze or a liquid glaze.

The salt glaze, which is the cheapest, is applied when the ware has nearly reached its highest temperature in the kiln; the fire is then managed, and when the right temperature is reached, common salt is thrown uniformly with shovels through holes at the top of the kiln. A moderate sized oven requires about 150 lbs. salt. The steam in the smoke decomposes the volatilized salt into chlorhydric acid and soda, which unites with the silica of the clay, and forms a thin film of soda glass on the surface of the ware. Silicious clays take the glaze best and become the most lustrous. When nearly half the salt has been thrown in, the fire is increased for a moment, then again reduced and some of the specimens examined. Then the remainder is thrown in, part at the top and part over the fire. All openings are then carefully closed and the oven cooled off for four or five days.

The liquid glaze, containing oxide of lead, clay, and felspar, sometimes borax, and diversely colored by metallic oxides, is applied by dipping the vessel in it before burning. This constitutes the Bristol ware of smoother surface.

Berthier mentions a glaze containing:

Silica	56	per cent.
Alumina	7	"
Lime	21	"
Magnesia	1	"
Oxide of iron	12	"
Oxide of manganese	3	"

Ground cinder, and slag from iron furnaces and mills are sometimes used.

Potash, saltpetre, soda, basalt powder, have been recommended.

The glaze is applied sometimes on the inside of vessels only, as making them less liable to crack under alternations of temperature.

At Quimper, a felspathic body is used, and the glaze contains no lead, as follows: Sand, 62; carbonate of soda, 20; kaolin, 8; lime, 8; borax, 2. Felspar, when introduced, opposes shrinkage, less flint can be used, it is easier ground, and the firing requires less heat.

The washing of impure kaolins gives a fusible felspathic sand, which may be used.

Felspathic bodies have an affinity for boracic glazes. The stone-ware on exhibition is remarkable for the perfection to which the industry has been brought, and the new practical uses to which this material is put with advantage.

The machinery used is represented only by two potter's wheels, several crushing machines, and Boulton's patent jigger. Drain pipes up to 30 inches in diameter are made by forcing a piston by steam or otherwise through a mass of clay enclosed in an iron box, in the bottom of which is an opening of the exact external section of the pipe. The sockets are afterwards added on by hand. Siphons and intricate fitments are made in moulds.

The water cisterns, acid pumps and tanks, distilling apparatus, egg-shaped sewer pipe, Doulton's lipped invert-blocks for sewers, with channels to separate the surface wash from the sewage when the latter has to be pumped in order to utilize it; a revolving churn, said to act rapidly; pipes to be built up in towers for the storage of muriatic acid, are all worthy of particular mention. (For further details see list of Exhibitors.) The impermeability of the material, its power to withstand the action of most acids, and, to some extent, of sudden changes of temperature without cracking, and the possibility of grinding the surface perfectly true, are its chief qualities for these uses.

Stone-ware and earthen-ware manufacturers will be interested in the following account from the *Staffordshire Advertiser*, of the New Over House Manufactory, Burslem:

"It stands upon about an acre of ground, and all the buildings are *en suite*—that is to say, from the clay bank to the packing-house all the processes are carried on in buildings which are arranged in consecutive order. This leads to a great economy of space, time, and labor. Commencing at the slip-house, we found the machinery arranged in two stories, and driven by a 30-horse power engine, supplied from two boilers fitted with smoke-consuming doors. All the materials required are ground upon the premises, and there are two 24-chamber clay presses in constant operation..... The slip-house communicates direct with the clay workshops, a range of buildings 143 ft. by 27. On the ground floor occur the throwing, turning, and handling shop, the throwers' hot-house, and the flat-pressers' workroom. It is in these departments that some of the most ingenious and useful of recent scientific inventions appear, and for these, producer and consumer (for the benefit is shared by both) are indebted to the engineering ability of the patentee, Mr. Wm. Boulton, of Burslem. For the first time, Mr. Boulton has applied a new invention to the throwers' wheel.....It is exceedingly ingenious, and is under perfect control by means of a treadle. In the flat-pressers' room, there are 12 jiggers and 2 whirlers driven by a supplementary engine of 6-horse power. The whole of these appliances are worked by an invention of Mr. Boulton, which may be thus described: An endless band passes down each side of the workshop under the floor, and is operated upon by means of two descriptions of grooved pulleys. There is beneath each jigger a driving pulley, and there is also nearly opposite to that a friction pulley, and this latter is attached to the upright spindle which communicates the motive power to the jigger. When the workman desires to set the jigger in motion, he presses his left leg slightly, and after a time, almost involuntarily, against a lever, which action has the effect of curving the endless band, and bringing it into contact with the friction pulley. The jigger, of course, revolves at once, but the workman, by means of the lever just mentioned, has the speed under complete control, and can regulate it to the greatest nicety. If necessary, a treadle can be used in place of the knee lever. By this invention the workmen are delivered from the annoyances inseparable from the employment of unpunctual and inattentive boys as jigger turners; there is also a moral and physical advantage as compared with the old plan of engaging women to work the treadles, and assist the workmen. Provision is made in the second story for nineteen hollow-ware pressers, whose workshop runs nearly the whole length of the range, and is probably the finest workroom in the Potteries, the height to the apex of the roof being 23 ft. We were not at all surprised to hear from Mr. Hammersley that the mere fact of such a noble room being provided enabled him to secure, without difficulty, the most respectable workmen. Lap stoves are used, and they are heated by exhaust steam.....Mr. Boulton has succeeded in warming and heating the whole of the works by means of iron pipes, along which the exhaust steam is conveyed.....There are two biscuit ovens and three glost ovens, the latter of which are built on the cone principle. There are four warehouses: the hollow biscuit warehouse, 121 ft. by 28; the flat biscuit warehouse, 60 ft. by 28; a smaller warehouse for sorting, and the principal warehouse, a room of 164 ft. by 33. Provision is made for twelve printers; and in the sagger-house, which is the last place reached by the steam pipes, 40 scores of saggers are dried at one time. The manufactory has an extensive frontage to the road.....The tympanum is filled in with R. Minton, Taylor & Co.'s encaustic tiles. All the roads and footpaths on the factory are paved and bricked, and, indeed, it may be stated summarily, that no expense has been spared to make this factory one of the most complete, substantial, and in some parts handsome, buildings in the district."

The decoration of stone-ware by grotesque figures moulded separately and superimposed before burning is well-known. Decoration in colors is hard to obtain on account of the destructive action of the intense heat and the glaze employed. Messrs. Doulton & Co. produce a "Claret" stone-ware, by the use of oxide of chromium, which is green before burning. Also, by tracing a design with a steel point on the clay itself, and applying oxide of cobalt with a fine brush, they obtain an effective method of decoration, in keeping with the character of the ware.

(See list of Exhibitors.)

TERRO-METALLIC WARE.—BLUE BRICKS.

Terro-metallic ware is of a dense, vitreous, non-absorbent, very hard and durable body. It is for some purposes superior to the best stone, and is particularly adapted for road and stable pavements, copings, tiles, channel courses, solid walls and hydraulic constructions. The tiles resemble cast iron in hardness and exceed it in durability, as incapable of rusting.

The material used is a natural clay, highly impregnated with iron, and sometimes with lime, and is more fusible than ordinary brick-clay. Clays which contain a large portion of elements soluble in chlorhydric acid are good for this purpose. Where these are not obtainable, lime and iron, in the shape of slag ground, are mixed with a fat clay. In England, chalk dust, sifted coke dust, and mill cinder are used. Pugging and moulding is done by machinery.

The firing requires a high vitrifying temperature, and fuel is a heavy item, unless kilns on the continuous principle are used. A kiln with down-draught flame, from which the waste gases are conducted to a second kiln, is found economical by Eckhardt.

The same substance will produce an ordinary red brick, blue ware, or a glass, according to the mode and degree of firing. For terro-metallic ware, the heat is first brought to a point at which the ware begins to soften and run together, then lowered to dark red, again raised and lowered many times.

Wood and clean peat are best; coking coal is hard to manage, as the intermittence in heat is obtained by successive heavy charges of fuel which are allowed to burn low.

In Holland, the firing is roughly done in open kilns, with walls 6 feet thick and 12 feet high. 100,000 bricks are burnt at a time, requiring often six weeks. This method gives considerable loss in melted and unburnt bricks.

In Germany, a rectangular kiln, with arched roof, containing 90,000 bricks, is used. The walls are 4 feet thick. There are 60 flue openings in the roof, and 20 fire-place openings at the sides, without grates; peat is used as fuel, continuously at first for 8 days, then charged intermittently every 4 hours for 4 days, and finally every 2 hours for 2 days. During the last period the flame issues abundantly from the roof.

At Rouen, the Hoffman annular kiln is used.

Blue-bricks are abundantly made in Staffordshire from a ferruginous clay which fuses at a china biscuit heat.

The blue color does not permeate the body as for terro-metallic ware, but only extends to about one-eighth of an inch from the surface. The fire is managed in a series of "pinches," but requires to be less intense. The blue color is obtained by repeatedly submitting the ware when highly heated to a reducing atmosphere of smoke, which reduces the red peroxide of iron to protoxide, all the salts of which are bluish and greenish. Sulphur assists this action.

In Holland the process consists in closing the dampers, and throwing bundles of wood into the fire shortly before the end of the firing.

FIRE-CLAY WARES.

The extensive use of fire-clay wares in most of the arts gives peculiar interest to their manufacture. The obtainable quality of refractory goods has, in certain industries, a controlling influence upon the economic results.

The fire-brick industry of England is chiefly centred in the productions of Stourbridge and New Castle, which together make 110 millions fire-bricks per annum, and export over $500,000 of fire-clay and 10 millions fire-bricks.

Fire-Clays.—In the present state of knowledge, the physical tests of clays give us better indications of its value than the chemical.

Clays of the same chemical composition are sometimes of opposite refractory qualities, while clays of different composition may be equally refractory.

When Brongniart and Malaguti mixed the correct chemical elements of porcelain together, and tried to reproduce that substance, they failed signally, and obtained only a non-plastic and very fusible substance. This also shows how greatly the properties of a body depend on the mode of grouping of the elements. The analyses of fire-clays, in chemical works, give merely the elements, and are therefore not presented in a practical shape to the manufacturer.

In examining a refractory clay, the purpose for which it is intended should be considered, for a material will answer for certain conditions that will not for others. Lightness of color indicates little; when owing to lime, it is generally a source of fusibility. Experiment should be made whether the clay is best alone, or mixed with other clay, raw or burnt, and in what proportion; what size to give to the fragments of burnt clay or quartz added; the finer it is the more it tends to combine chemically, especially quartz. The addition of large fragments produces a more porous and brittle brick, which stands better changes of temperature, and is preferred for blast-furnace boshes, &c.; fine burnt clay makes a denser brick, which retains heat better, and is preferred for coke-ovens, &c.

The corroding influence of the metals and slags to which the fire-brick is exposed, must be combated by careful preparation of the clay, to produce a denser brick, by giving superficial smoothness, and by hard burning.

In building with fire-brick, the use for joints of cement containing free silicic acid (quartz) should be avoided, by previously saturating the cement with a basic burnt clay. Bricks analyzed before and after use, have shown a loss of half the silica they contained. A test of the power of brick to withstand these corrosive influences, is the number of times it can be melted up with oxide of lead, without being eaten through.

In examining the analysis of fire-clays, attention should be paid to the proportion of sand, which makes them more meagre, and opposes rupture, while burning. An excess of sand renders them more brittle and porous, yet they stand heat better. The sharpness and size of the grains facilitates a homogeneous composition by rubbing when being worked up. Clean quartz sand is the best; ground sandstone is good, but expensive.

A high proportion of alumina increases the plasticity of clay, and, at high temperatures, also the refractory power. Thus monosilicates are more refractory than bi or tri-silicates. Free silica, *i. e.*, in crystals mechanically mixed, must be distinguished from combined silica.

Increasing the proportion of combined silica, augments the resistance in the fire only at lower temperatures, which, however, may often suffice in industry. But above the point of melting steel, the more combined silica there is, the greater is the fusibility. Also, the ware then requires a longer burning in the kiln.

Clean free silica will not melt in our melting heats, unless fluxed. A high proportion of free silica is less injurious than when the silica is combined. Silica which has been long in the fire is more refractory and incorrodible.

Bischof finds that any addition of fluxes above 4 per cent. rapidly increases the fusibility of the clay, in the following order: lime, magnesia, alkali, and oxide of iron least. Richter finds them damaging, as follows: magnesia most, lime next, then iron oxide and alkali.

Analysis of Fire-clays.	Gartsherrie, by Schwarz.	Stourbridge, F. Abel, Salvetat, etc.	Poole, Dorsetshire, by Weston.	Teignmouth, Devon, by Weston.	Kaolin, by Couper.	Tahier.	Mazet.	Montereau, by Berthier.	Rhine, Hesse, and Nassau.	Passau, by Knaffl, etc.	Saarau, by Richter.	Meissen, by Salvetat.	Ruditz (Austria), by Gohren.
Alumina	28.95	19 to 38	32.11	29.38	39.74	26	25	24.6	15 to 37	31	38.29	20.92	34.75
Silica	59.48	63 to 70	48.99	52.06	46.32	56	52	64.4	32 to 77	50	35.70	61.52	52.80
Sand	..	....	..	..	..	2.0	9.8	..	0 to 54	..	4.40	..	..
Lime	trace	0 to 0.7	0.43	0.43	0.36	..	..	..	0 to 4.5	1	trace.	1.25	0.31
Magnesia	..	0 to 0.2	0.22	0.02	0.44	2.0	trace	..	0 to 1.5	1	..	..	0.07
Iron oxide	1.05	2 to 7	2.34	2.37	0.27	..	..	trace	0 to 4	2	1.01	1.75	1.53
Potash	..	0 to 3	3.31	2.29	..	..	..	..	0 to 3	3	1.11	..	..
Soda	..	....	2.33	2.56	..	..	..	..	0 to 1.5	..	..	..	..
Water combined	11.05	10 to 16	9.63	10.27	12.67	14.0	12.6	..	5 to 15	14	19.49	..	11.81
Water hygroscopic	..		..	..	12.08	..	..	10	..	..	..	..	..
Organic substances	..	....	..	..	..	..	..	..	0 to 4	..	..	..	..
Carbon	..	0 to 1.8	..	..	..	..	..	..	..	..	..	..	..

The Garnkirk clay (near Gartsherrie, Scotland) is bituminous and mixed with some sulphur and almost free of sand. After weathering for two or three years, it is used almost dry and without addition of burnt clay. It is the most refractory clay known.

The Stourbridge clays, also of the coal formation, are carefully sorted at the pit into three numbers. The best is for glass-house pots and blast-furnaces, and costs fifty-five shillings a ton on the spot. The second is for cupolas and fine wares. The ordinary clay costs ten shillings a ton, and four tons of it make a thousand nine-inch brick. The two first are mixed with "grog" before use. The first, after grinding, is kept under cover.

The Cornwall fire-bricks are made of: 1 clay of Poole, 1 clay of Teignmouth, and 2 of clean sand.

Belgian fire-clay (the best are Tahier and Mazet) is found in the chalk formation, in pockets of some 200 feet diameter. The best is white, grey and black. It is sometimes used without grog. It has superior qualities for zinc distilleries.

France—Montereau and others are good.

Germany—The clays are inferior for some uses. The graphite crucibles of Passau clay (Bavaria) are excellent. 100 Silesian clay of Saarau, with 150 of sand, makes excellent fire-brick.

Austrian clays resemble the English in qualities and composition.

Sweden possesses, near Högenäs, clays superior to the Stourbridge, and nearly equal to the Garnkirk.

MANUFACTURE.

In England, the clay, after weathering, is ground to $\frac{1}{8}$ of an inch by passing between or under crushing rollers weighing three tons, and sifted at six meshes to one inch for brick, and fourteen to one inch for glass pots.

The grog is then added, and it is tempered with water. The pugging is done by treading and beating, or generally in a cast-iron pug-mill driven by steam (2.5 to 3 horse-power will pug eight tons of clay in ten hours, the clay remaining three or four hours in the machine.)

The bricks are moulded by hand. Steam-presses have been devised (Daelen's.)

Fire-bricks, when too porous, may allow molten slag to filter through. This is obviated by increasing the density by homogeneous preparation, beating, kneading, and hard-firing; but this also increases brittleness.

Clays rich in silica are to be avoided for glass manufacture, as they are sooner attacked by the glass, are more brittle, and burn less hard. Fatter clays, with the addition of burnt clay, are better.

The fuel, and the mode of applying the flame, from below or from the side, has different effects.

The addition of serpentine, talc, graphite, coke, coal, charcoal, etc., heightens the refractory power of brick.

By treating with acids, inferior qualities of fire-clay, they have been much improved, by the solution and removal of detrimental parts.

The burnt clay added, should be burnt as hard as possible, so that it may not again contract in firing. In Belgium, for ordinary fire-brick, the burnt clay is reduced to $\frac{1}{8}$ or $\frac{1}{12}$ of an inch; for muffles to $\frac{1}{6}$ or $\frac{1}{8}$, and well beaten in. At Andennes the sieves have twenty-five to eighty-eight openings per square inch.

For best brick, in Westphalia, to 1 of fire-clay, 2 of burnt clay are added. In Belgium, to 31 of clay, are added 52 burnt clay, and 17 clean quartz.

The drying of bricks, in Scotland and at Stourbridge, takes place in sheds or rooms, with hot air flues in the floor. For zinc retorts, the drying is very gradual, lasting several months, and the temperature increasing from 80° to 120° F. For certain uses (zinc retorts, &c.) the wares are only dried, and not burnt. A glaze composed of 40 white lead, 36 granite, 12 flint, 4 glass, is sometimes applied to one side of the ware.

Walls and arches of large glass ovens are made of Stourbridge clay, shaped into large slabs, and dried for a year or more, but not burnt.

The burning takes place at Garnkirk, in rectangular kilns; the flame enters and ascends at the side, between the bricks, descends in the centre, and thence enters two chimneys. At Stourbridge the kilns are circular-domed cupolas. The flame is everywhere separated from the ware by thin walls; it enters at the circumference, from 8 or 10 steep inclined grates, passes first under the floor, ascends into an annular space, which is separated by a thin wall from the middle of the oven, and passes to the chimney through a vertical flue and holes in the floor. The inner shell of the oven is closed on top, and has one door at the side. From 12,000 to 35,000 bricks are introduced; the temperature is raised gradually, maintained 80 hours at a white heat, and cooled down for 7 days. The capacity of the kiln is such that one cubic foot of space is allowed per 10 bricks. The coal is obtained from the same pits as the clay.

In Belgium two kinds of kiln are in use. Those with a fire under an arched floor, having openings through it, work the fastest, and consume 8 or 10 pounds fuel for 100 pounds brick. Hoffman's kilns are also used. The duration of the firing varies, large grained ware burning more rapidly.

Plumbago Crucibles.—Graphite is added to the fire-clay, that of Ceylon is used in England; it gives the most refractory product, is used for melting crucibles, and withstands changes of temperature. It is essential to purify it from oxides or fluxes; this is done by alkaline, followed by acid washes. Old plumbago crucibles ground up are also used.

The Passau crucibles are made of $\frac{1}{2}$ to $\frac{1}{3}$ Passau clay and $\frac{1}{2}$ to $\frac{1}{3}$ graphite. The Patent Plumbago Crucible Co., London, manufacture ware containing 52.6 carbon, 2.08 hygroscopic water, and 45.40 earthy parts, which consist of 68 per cent. silica, 31 alumina, 0.5 iron oxide, and a trace of lime. They are burned without contact of the flame.

Plumbago crucibles withstand great alternations of temperature, and absorb metals much less than fire-clay.

Coke, coal, and charcoal are used as substitutes for graphites, but more than 10 per cent. can not be used, as it is burnt out more easily than graphite, and makes a too porous ware.

In Hanover, at Sollingerhutte, excellent crucibles are made of 9 parts fire-clay, 14 burnt clay, 6 charcoal. In Bavaria, a good crucible is made of 14 clay, 10 old brick, 8 quartz, 2 coke.

For lining lead furnaces and brick kilns, sifted coke dust slipped with clay is used.

Very refractory crucibles are also made, without any clay, of coal, or coke powder alone, with glue, and burnt without contact of the air.

At Beaufay dense crucibles are made of clay raw and clay burnt, and being poor in silica, they withstand corrosion. Although dense, they withstand sudden changes of heat. They contain silica 64.6, alumina 34.4, iron oxide 1. (Berthier.)

Silicious Fire-Brick.—The Dinas fire-bricks, which consist of 96 per cent. pure silica, with a little lime and iron, possess the highest refractory powers, but will not stand alternations of temperature nor the action of basic slags, such as those of metals or lead ores.

The Dinas sandstone consists of 98 to 96 silica, 1 alumina, 0.2 lime, 0.5 iron oxide, 0.2 alkali, 0.5 water. This stone is heated in quantities of 15 tons in a Rumford oven. A continuous kiln, as for lime, may be used to advantage and brought in 12 hours to a red heat, then thrown at once into water; the fragments are washed by a hand machine and sorted by hand, the cleanest being chosen for first quality of bricks. They are next crushed to a rough powder between iron rollers, and 1 per cent. of lime and water is added. The workmen with gloves put this paste into moulds, placed on an iron table, where it is firmly compressed by a stamp.

After drying, the bricks are burned hard for 7 days. They expand in burning, yet are very dense. The introduction of large fragments of quartz in bricks, causes rupture from expansion. The fracture is rough and presents grains of quartz imbedded in a yellowish cement.

The manufacture is newly carried on at Stolberg, near Aix, and the Templeton Silica Works exhibit bricks analogous to the Dinas.

Excellent bricks are also made of clean quartz with an addition of a little clay. The Martin Bros., England, make brick of refuse kaolin and selected washed sand. They are formed of 76 silica, 21 alumina, 1.7 iron oxide. Vygen & Co. (Duisburg) make excellent brick, containing 85 silica, 13 alumina, 2 lime.

For lining Bessemer converters, a Sheffield sandstone is mixed with 1 or 2 per cent. of alumina and oxide of iron.

Other Fire-Brick.—To avoid the introduction of silicium and carbon, so detrimental to many metals, fire-bricks and crucibles are made with success by adding to fire-clay, either magnesite, halloisite, asbestin (a plastic magnesian silicate) or bauxite.

Deville obtains excellent crucibles by mixing equal parts of sulphurous or cryolitic clay and marble. To 1 part of this mixture burnt very hard is added 1 alumina and 1 gelatinous silica saturated with ammonia and alum, and when burnt once, withstands all changes of temperature.

A novelty in fire-clay gas retorts, are the internal ribs of Fraser, for strengthening and conducting the heat rapidly; made by the Farnley Iron Co. (See Exhibitors.)

BRICKS.

Somewhat meagre clays, containing a certain amount of oxide of iron and lime, are usually chosen. Although fatter clays are easily moulded, they shrink more, and even crack in the fire. The fluxes, iron, lime, &c., are useful, as they produce a solid brick at a lower temperature.

Although the clays of each particular locality are almost of necessity used for brick-making, a knowledge of their adaptability to each kind of brick is essential.

Sandy clays, containing 60 to 96 per cent. of sand, besides some lime and iron, produce bricks which are cheap, and stand fire better than weather, for they are absorptive and brittle. These clays may be differently used, according to the nature of the silica they contain:

1st. If in the mealy or finely divided state, it will not make brick, except for polishing, as Bath brick and Tripoli stone.

2d. If the silica is amorphous and fusible (such clays then possess more parts soluble in acids) the clay will run together in the fire, and may be eminently adapted for making terro-metallic ware (which see).

3d. If the silica is in the shape of crystalline sand, by washing out some $\frac{2}{3}$ of it, the remainder will be unctuous and fat, and, with or without an addition of sand, it can be worked into a good brick (more fuel is then required). Or else it may be used unwashed, but mixed with a fat clay. 4th. If the clay contains much mineral dust, washing will not separate it, and the bricks will not be durable, unless burnt to vitrification, as in terro-metallic and blue ware.

Brick clays contain not too much sand (5 to 60, sometimes 80, usually about 25 per cent.), the silica and alumina are about in the ratio of 3 to 1, and there is 1 to 2 per cent. of lime. When they contain 20 per cent. lime they become limey clays and are not used for ordinary brick, as they would fall to pieces by slaking of the lime. A certain percentage of lime and iron is, however, useful. To make use of limey clays for brick, as it would be too expensive to wash out the lime, the only resource is to mix them with other clays, so as to reduce the percentage below 20 per cent., or else use them for terro-metallic and blue ware. If the use of limey clay alone, cannot be avoided, it should be burnt at a temperature low enough not to expel the carbonic acid; the brick will then contain carbonate of lime, which does not slake; but such bricks are treacherous.

Lumps of gypsum in a brick will destroy it. Pebbles and fragments of flint cause the brick to fly in firing.

Pottery clays are expensive for brick, as their shrinkage must be combated by the addition of sand, meagre clays, etc. For thin ware, such as roofing tiles, they may be used advantageously alone.

Fat brick clay also requires sand, meagre clay, anthracite cinders, etc., to be added.

Test of Clays for Brick-making.—Several bricks are made and placed at various points of the oven. The economical medium between fusibility on the one hand, and sufficient facility of working on the other, is sought for.

Clay that feels slippery between the teeth and cracks in the oven is too fat. Clay that feels gritty and burns to a porous, crumbly brick, is too meagre; in this case, it can be improved by applying pressure, and if at the same time it contains the right amount of lime, which will combine chemically at a higher heat, a most durable brick results, which may contain even 85 per cent. sand.

A good brick is known by its hardness, solidity, perfect faces and edges. Cold and dampness will not split it off in scales. It must not be too heavy and dense. Striking with the hammer in one direction affords an essential test of homogeneity by the fracture, which should occur in that direction, and when machine-made bricks will not stand this test, they are not durable. For flooring and vaulting, lightness is very desirable. Hydraulic masonry and pavements require greater density and superior vitrification.

A clear ringing tone when struck, indicates solidity. A dull sound, weakness. The fracture should be homogeneous. Resistance to crushing, to acids, to scaling off when plunged in Glauber salts, and to weathering, are further tests.

Bricks stand weathering best when they contain but little lime (unless highly burnt) and are not laid in lime-mortar.

The durability of Roman brick is attributed to their great homogeneity.

A simple chemical analysis assists greatly in ascertaining the value of a clay for brick.

Manufacture.—The quality of a brick depends largely upon the preparatory processes of weathering, crushing, mixing, pugging with cold or hot water, by hand or steam.

Long weathering in winter is sometimes replaced by sun-drying or by heating the clay artificially and then watering it, or by pugging with water at 160° F. in a steam-heated cylinder.

Crushing rolls, first used in England and now spread through Germany, are essential.

Moulding by Hand.—In Germany 7 men mould in a day 10,000 bricks. Near Paris, 4 men make 7,000 bricks in 12 hours.

In the London brick-field, 4 men and 3 boys, constitute a "stool." Of these, only one is at the mould, the others are engaged in bringing the clay from the pug-mill (driven by one horse per stool) and in carrying off and stacking the bricks. 7,000 bricks per day of 12 hours is considered good work for one stool. This labor is paid about $1.25 per 1,000.

In Westphalia, an iron mould is fastened to a table; an iron piston connected with a lever worked easily by the moulder's foot, empties the contents of the mould upon a board. The brick is carried off between two boards, and set up on edge to dry. One man moulds 3,000 per day. The German bricks are larger than the French or Dutch.

In France an iron mould with hinged sides is used; it makes a smooth brick, as the mould is opened sideways and is never drawn off.

When the brick is moulded close to the lower opening of the pug-mill, and wheeled off on a track, one moulder with two men to fill the pug-mill, one man to rough-shape and hand him the clay, and one man to wheel off the moulded bricks, can make and stack 3,500 German bricks per day.

If the clay is worked too stiff, the bricks may look better, but are less homogeneous and durable. In England the clay is worked in a more plastic state than in Germany.

Machine-made Bricks. — Machines have to compete with the preceding elements of hand-moulding.

The advantage of machine over hand labor may be considered fully established in all departments of brick-making except digging the clay and moulding the brick; the latter seems the only debatable operation.

Meagre clays and those requiring much working up are better adapted to machine work.

Bricks made from fat and mixed clays seem more apt to crack when machine-made.

The relative merits of machine and hand make are not settled. Resistance to crushing has been investigated and found equal, by a Bavarian Commission, and in favor of the machine, by an English Commission. In point of economy, the following are obstacles to moulding by machinery:

1st. A stationary machine requires excessive transportation of raw and finished material.

2d. Interest, and sometimes wages, on machinery idle six months. Also repairs.

3d. Some 15 per cent. more raw material is required, if bricks are denser, as often occurs.

4th. Protection from unequal wind and sun in drying is indispensable.

With a large production and a well-chosen machine these difficulties are overcome.

Brick-Machines.—Salvetat, Malpeyre, etc., have classified these machines differently. The most comprehensive division seems to be into: 1st. Compressive, 2d. Expressing machinery.

The first class imitates hand-work by driving the clay into moulds, and subdivides itself into the dry and moist processes.

The second class forces clay through a die, in a continuous stream, which is cut into separate bricks by a cutter.

The first method only presses, the second only shapes the brick. Each has its advocate; a combination of the two may be desirable (Duberg), as for hand-made bricks, namely, first shape the brick and then press it.

The dry process (Gregg, Durand, Davis, McHenry) is adapted to sandy and meagre clays, when they are homogeneous, and is then cheapest. Otherwise, the moist process gives a more uniform and durable brick. For the moist process, expression is cheaper and better than compression.

Besides the expressing machines exhibited, which are described further on, those of Hertel, Schlickeysen and Sachsenberg have obtained some success in Germany.

The Hertel machine works up the clay more and delivers it best of the three. The clay is crushed, cut up, and expressed by screw motion (Clayton expresses by a piston), and with eight or ten-horse power, 1000 bricks per hour are made.

Drying, in the open air, requires a material that will stand unequal sun, rain and winds. Bricks dry faster when set on edge. In England, two layers of bricks three inches thick are set up daily, until they are walled eight or twelve high. Drying by artificial heat produces uniformity of shape, and is economical when waste heat is applied. Fans are sometimes used for the purpose (see Annex).

Facing bricks may be smoothed and stained red uniformly, by dipping when dry in a clay slip containing iron oxide, or lead oxide and dextrine; black, as practised in Germany, by dipping hot in boiling tar. Pressing, when dry, improves the surfaces.

Glazed bricks.—A glaze of a nature more fusible than the body, is applied to the surface of the dried brick (see Earthenware). A salt glaze can be applied in the same way as for stone-ware. Salt, followed by oxide of lead thrown into the oven, produces a more brilliant glaze.

Burning.—For kilns, etc., see description of those exhibited. According to the temperature of the oven, the same material gives a brick, blue-ware, or glass.

At a certain temperature the silica combines with the lime, iron, etc., and forms stable silicates. Sometimes 2200° F. is required. The color of the brick (see Blue-ware) depends much upon the firing. By dipping in a clay slip a uniform color can be obtained. Insufficiently burnt bricks are known by their solubility in acids, showing the non-formation of the durable silicates.

The walls of the kiln should be air-tight, to prevent air from entering and lowering the temperature. To realize this, an isolating layer of sand or concrete may be introduced in the wall, which will also retain heat. Porous walls 3 to 7 feet thick, of meagre or sandy clay mixed with coke or coal dust, coated with 4 inches of sand, and cased outside with brick, are recommended for their non-conductibility of heat.

By setting the bricks close together ($\frac{1}{4}$ inch apart) in the kiln, fuel and space is saved, fusible bricks are less apt to run, and the color is more uniform. If bricks have not been thoroughly dried, they crack in the oven. The required draught is usually obtained more cheaply by a chimney than by a fan. Nevertheless Buhrer & Hamel and Muller & Gillardoni use kilns composed, like Hoffman's, of a series of chambers, communicating with a central flue, with the difference that a fan exhausts the gases thence and delivers them into drying rooms.

DIMENSIONS OF BRICKS.

It is questionable whether the size of $8 \times 4 \times 2\frac{1}{2}$ inches, commonly used in the United States, is really adapted to form the most solid walls.

$10 \times 4 \times 2\frac{2}{3}$ in. is considered a proper size in Germany. In Austria, the bricks and joints are much larger than with us. In modern Italy, besides the size of $9 \times 4\frac{1}{2} \times 2\frac{1}{4}$ a larger one of $12 \times 5 \times 1\frac{1}{2}$ is much used for arches and cornices and the mortar joint is $\frac{1}{2}$ to $\frac{3}{4}$ in. thick.

The solidity of the constructions of ancient Rome may owe something to the size of the brick, which for arches are 16 inches in length and more.

The ancient Babylonian bricks are 13 in. square and 3 in. thick. The paving bricks are 18 to 24 in. square. The wedge-shaped bricks with curved tops and bottoms, used by the ancient Chaldeans for arches, are well adapted for strength and finish, besides saving labor in turning the arches.

An 8 inch brick will produce by its bond a stronger wall, only if the wall be thin. But 24 and 30 inch walls would perhaps be stronger as well as easier to build, with larger bricks.

Arches made of single 16 inch bricks are more solid than when made of two concentric arches each 8 inches thick, and are also more easily built.

TUBULAR OR PERFORATED BRICKS.

Whether for light floor vaulting and partitions, for ventilation and chimney flues, or to exclude cold by the layers of air they contain, the property of saving some 33 per cent. in raw material, in coal, in time of drying, and in weight, makes these bricks invaluable.

They are stronger than solid brick for the same section Numerous small holes, say 24 to 48, are better for strength than a few large ones.

To diminish the consumption of mortar, and present a smooth face, the holes are sometimes closed up on five faces and left open only on the sixth. Expressing brick machines are used. The clay requires more preparation than for solid brick. Hexagonal hollow tubes are a variety of this ware.

LIGHT POROUS BRICKS.

Being light and poor conductors of heat, they serve for vaulting, flooring and chimney stacks.

They hold mortar, and stand fire well, but weather ill, unless made of infusorial silex.

Infusorial silex, found near Luneburg (80 silica and 20 water, besides a few impurities), mixed with 4 per cent. of fat clay, makes a good brick. This infusorial silex, when raw, is a trifle lighter than water, but washed and dried, it weighs less than half; the bricks weigh $\frac{1}{4}$ of ordinary brick, shrink $\frac{1}{20}$, and are much used for arching in Berlin (Kerl).

By mixing organic substances, such as peat, coal, sawdust, straw, flax, and sometimes lignite ashes, etc., with clay, the firing consumes these, leaving numerous pores in the brick. According to the desired lightness and strength, 1 volume of fat or plastic clay is mixed with $\frac{1}{2}$ to 3 volumes of coal dust, etc. Sandy clay will not answer. A high porcelain heat is required, and the substances added to the clay assist greatly in producing this heat.

WATER COOLERS.

In Alcarazzas, Goolahs, etc., the porous body allows water to filter slowly through, which in hot climates evaporates rapidly and cools the jug. The pores should be fine enough to produce only a moist surface. The material used is either clay alone, or mixed with sand, organic and vegetable fibres, animal dung or salt Clay or river slime requires only a feeble firing.

Seven volumes clay powder, 7 volumes burnt fire clay, ½ volume saw dust, mixed and burned at a white heat gives a strong and porous body.

Cells for galvanic apparatus are similarly made, but limey clay is inadmissible.

Flower-pots, which, if glazed or impervious, are worth little, are made porous in the same way.

DRAIN PIPES.

They are made permeable, for draining wet ground, or impervious, for conducting water.

To produce a permeable channel two methods are available. The worst consists in selecting a meagre clay and half burning it; the porous body thus produced is weak and the pores soon fill up. The better way is to burn a stiff and fatter clay mixed with sand to a semi-vitreous state, and in putting together, leave passages for the water. The clay should be sifted through ½ inch holes.

The impervious ware has a fat or fire-clay body, covered internally with a glaze formed of 50 lead oxide, 45 sand, 2 bioxide of manganese.

Expressing brick machines are available for making drain pipes. Whitehead & Williams' machines are used in England and Germany for 4 in. and smaller pipes; they rest while the hopper is being charged. Clayton's machines are used for large pipes.

The pipes are dried slowly, and when stiff enough, are rolled with a core upon a table and then set up. For large pipes, a semicircle of wood is worked in the ends to make them circular and true. They are burnt in brick ovens.

ROOFING TILES.

In many countries earthen-ware tiles are used; for durability and cost they are often preferable to slate.

The clay is stiffer, fatter, and more carefully worked than for brick; it requires to stand weather better. Limey clays are excluded unless burnt to vitrification.

Imperviousness is essential. As vitrified ware is apt to warp, glazing is the readiest method of producing imperviousness. Salt and lead glazes last less than those made with oxides of iron and manganese, or with iron slag. Old tiles are less absorptive than new, as the pores become gradually filled.

The selection of the best form is important. Some shapes require more pitch to the roof.

The tiles are moulded by hand or by machine. The flat stream of clay issuing from the die is cut into plates, and these are pressed in a plaster mould. Plastic clay produces a more finished tile; stiff clay, pressed in metal moulds, dries faster and requires no boards.

The preparation of stiff clay consists chiefly in passing between rolls $\frac{1}{5}$ of an inch apart, heaping up, re-rolling several times between rolls $\frac{1}{25}$ of an inch apart, and treading under foot.

The tiles, being thinner than brick, require less heat to fire them. Six days in a simple closed kiln or in the less heated portions of a brick kiln, suffices. For vitrified tiles, they must not be piled up in the kiln or the shape will suffer.

Leaving tiles under water for several days is a test; limey tiles will appear scaly and be rejected.

The tiles may be stained red by an iron clay slip, or by 2 minium and 1 dextrine. Blue may be obtained as for blue bricks (which see). Black, by dipping the tile while hot in boiling tar. For blue-black tiles, see Ferro-metallic Ware.

A good dark brown glaze consists of 85 lead oxide and 15 manganese oxide slipped with clay. If two per cent. copper oxide be added the glaze will be black. They are applied upon the dry ware before burning.

Colored glazes applied upon burnt tiles that have stood the test of water are analogous to those for earthen-ware. They must be adapted by experiment to the composition of the tile; 40 to 60 per cent. lead oxide, with 10 to 20 quartz sand, 10 to 16 glass ground, and 10 to 20 of clay, salt, saltpetre, etc., gives a white glass, which may be variously colored by 2 to 5 per cent. of metallic oxides (see Colors), and applied as a glaze. By replacing $\frac{1}{4}$ of the lead, by tin, an opaque enamel results.

ANCIENT ARCHITECTURAL POTTERY.

The researches of Layard, Rawlinson, Rassam, Loftus, Place, Wilkinson, and others, have revealed much of the architecture and materials used by the ancient Assyrians, Chaldeans, and Egyptians.

The durability of earthen-ware and its colored glazes, the great use which can be made of colored decoration, and special-shaped bricks, in architecture, may be considered well established by their labors.

Durability.—The Assyrians kept minutely inscribed public records of conveyances of lands, deeds, &c., on cylinders and tablets of clay, which was afterwards baked. These furnish complete materials for deciphering the history and cuneiform writing of those times; a selection from these inscriptions is now being published by the Trustees of the British Museum. Perfect impression of seals pressed on the moist, and afterwards baked clay, are also found.

Inscribed earthen bowls from Babylon assist in historical researches on the Jews.

"To this day," says Layard, "there are men who have no other trade, than that of gathering bricks from this vast heap (the ruins of ancient Babylon), and taking them for sale to the neighboring towns and villages, and even to

Bagdad. There is scarcely a house in Hillah that is not almost entirely built with them. . . . . . Many bricks found in this ruin are coated with a thick enamel or glaze. The colors have resisted the effects of time, and preserve their original brightness."

Brick.—The three varieties of red, blue, and yellow, or fire-brick, were well known to the ancient Chaldeans; crude or sun-dried brick were used in large quantities.

In the tombs at Thebes, the process of brick-making is represented. The crude bricks were made with a simple wooden mould, stamped with the name of a king or high-priest, and then dried in the sun; and although no pressure was used while drying, their structure is most compact, and some have been found by Wilkinson as firm as when first made.

The Babylonian baked bricks are 13 in. square, and 3 in. thick. The sun-dried bricks are 6 to 16 in. square, and 2 to 7 in. thick. Besides these, which resemble the square thin shapes later used by the Romans, there were triangular bricks for corners of walls, and wedge-shaped bricks for arches, which are sometimes concave below and convex on top. For the casing of walls, burnt bricks were used; the crude bricks were reserved for the interior mass. The casing is often as much as 10 ft. thick.

The masonry was striped horizontally by thick layers of reed matting steeped in bitumen, inserted at every 4 or 5 ft. of height, to form the bond when crude brick were used, but never for burnt brick.

The crude bricks were laid in clay, sometimes mixed with chopped straw; the burnt bricks, in bitumen.

In the palace of Nimroud, sculptures are set on a crude brick platform, with an intervening layer of bitumen one inch thick.

The Assyrians at Kouyunjik used large kiln-burnt bricks, about 2 ft. square, for paving.

The Illahoon pyramid is of crude brick, also that of Dashoor.

The Hawara pyramid is of large brick, cased with stone.

Limestone was used for foundations, as it resists salts better than granite or sandstone.

Vaults are found, covered with a single piece of terra-cotta, of about 7 ft. by 4 ft.

Colored Decoration.—The distinctive feature of Babylonian architecture is the profuse employment of colored decoration. The Temple-towers of the Chaldeans were built in many stories, faced with enamelled bricks of colors corresponding to the planets, connected with each story. Copper bolts were used to fasten stone to brickwork, and copper nails for tiles.

In the Temple of the Moon at Mugheir, brick or tiles glazed with a blue enamel were fastened externally to walls of burnt brick. The building practice of to-day may study this temple with fruit. In the matter of cements, witness the care with which the whole lower story and the N. W. faces of the superstructure are laid in bitumen (to resist dampness); the other faces are laid in good lime-mortar (which hardens well, only when exposed to the air), while all the bricks of the inner masses (except foundation) are laid in cement of lime and ashes (ashes tend to make lime hydraulic, and as lime-mortar remains moist in the interior of walls, for years even, it would appear that the ashes were added to hasten the hardening of the interior).

The domestic dwellings of the Chaldeans, were ornamented externally by diapered patterns of colored bricks, sometimes moulded into half columns, with a variety of wavy patterns. Internally the plaster walls were embellished with colored cones of terra-cotta, imbedded in the plaster, so as to show either their bases, or their points, or a part of their sides, combined in lines.

The following process of painting on enamelled and embossed brickwork was also used. A subject was modelled on a large sheet of clay; the clay was cut up into bricks, which were stamped with guide-marks. The bricks were coated with the desired colored enamels, which vitrified in burning, and the whole bas-relief subject was then set up according to the guide-marks.

In ancient Egyptian decoration, the colors were primary colors—red, yellow and blue; only one secondary—green; to which black and white were added. By avoiding the mixture of tints, pleasing conventional effects, similar to Chinese decoration, were obtained.

Bold decided lines were the aim of Egyptian draughtsmen; broken dotted lines are not met with. Some of the lines of figures done at a single stroke are 15 inches long. The designs were first traced in red lines, and corrected in black.

EXHIBITORS OF ARCHITECTURAL TERRA-COTTA, STONE-WARE, FIRE-CLAY GOODS, TILES, AND MOSAIC BRICKS, Etc.

Blanchard & Co., 74 Blackfriars Road, London, exhibit in terra-cotta a complete angle of the main cornice of the Wedgwood Memorial Institute, Burslem. The architect, R. Edgar, and the manufacturer deserve credit for particularly artistic treatment of material. Also portions of main cornice of New Schools of Science, and of Lecture Theatre of S. Kensington Museum. There is a rough and ready stamp about their products.

Doulton & Co., High street, Lambeth, London, exhibit a terra-cotta "Amazon Vase" of colossal dimensions, elaborately modelled and skilfully moulded. Also an elegantly designed fountain. Their material is in every case of excellent manufacture. The designs are often comparatively deficient. They obtained medals in 1851, '62 and '67. Their stone-ware crucibles and blue bricks are well known. Their lipped invert blocks for sewers are a new feature. They exhibit stone-ware taps 9 inches in diameter. Also a remarkable plumbago crucible 6 feet high and 4 feet diameter.

Jas. Pulham, Broxbourne, exhibits a built window setting in moulded blocks of pale terra-cotta, equal in appearance to stone, ornamented by a mask of conventionalized floral ornaments in red clay. Also a Preston vase and pedestal, all of good partly vitrified material.

JAS STIFF & SON, Lambeth, London, make a pretty effect of red colored clays inlaid on a buff body, for arch blocks. The difficulty of difference in shrinkage they appear to have overcome. They exhibit also highly vitrified chemical apparatus, sewer pipes, chimney finials, etc.

J. CLIFF & SON, Wortley, near Leeds, make large egg-shaped stone-ware drain pipes, gas retorts, crucibles, etc., and terra-cotta.

THE WATCOMBE TERRA-COTTA CLAY CO. have found an excellent red clay material near Torquay. The specimen-shown are of pure unmixed clay. The surface is hard and somewhat slippery. The clay will not stand as much fire as buff terra-cotta, nor the test of the point of a knife. Two remarkable baskets of flowers in terra-cotta are shown, which indicate unusual plastic qualities in the clay, and may be considered a triumph of the potter's art.

E. MARCH, Charlottenburg, near Berlin, makes a fine exhibit of pale biscuit tint terra-cotta, of excellent body and firing. Also photographs proving the extensive use of terra-cotta at Berlin. His statuettes, capitals, consoles, are good, and a large fluted ornamented column of great merit, price $50, are noticeable. Also a tablet with incised ornament in dark clay.

V. BRAUSEWETTER, Wagram, Austria, exhibits some admirably moulded terra-cotta brackets and vases; the body is of a rich deep buff color, and of superior texture. This exhibitor distances his competitors in excellence of design and color of material.

GIBBS & CANNING, of Tamworth, have supplied a large amount of terra-cotta for the Albert Hall and Arcades of Royal Horticultural Gardens. The color is excellent. They adhere closely to the models given them. The firing is somewhat unequal. Their hexagon pots of thin terra-cotta to fill in the spandrels of vaulting are light and excellent, and extensively used at Manchester.

J. BLACKMORE, Manchester, has a patent glazed earthen-ware cistern for both hot and cold water, which is better for the purpose than metal, since it will not injure the water like lead, or rust like iron.

Lilliehill Terra-Cotta Co., of Dumfermline, have a bust of Apollo, and a terra-cotta vase of some merit.

J. Knowles, of Wooden Box, Gothic tracery and chimney pots, of well burned Derbyshire fire-clay, and remarkably lustrous stone-ware.

W. T. Holland, Ynisymuda, Swansea, Wales, exhibits chimney tops, ridge tiles, vases, and fountains, all good.

Whitewick Colliery Co., Coalville, near Leicester, exhibit a material of mixed clays, called Glypto terra-cotta. The body is too soft and porous to compete with other terra-cottas. The designs of chimney finials have some merit.

H. Pether, Belvidere Road, Lambeth, Surrey, exhibits some patent bricks which resemble terra-cotta. A simple pattern is stamped on them.

I. C. Bailey, Fultham Pottery, London, exhibits chemical stone-ware, ale bottles, and terra-cotta goods in abundance. Also a terra-cotta gas stove 2 ft. 6 in. high, price $3.50.

The Patent Plumbago Crucible Co., Battersea, London exhibit Morgan's crucibles for melting and refining metal, and nests of round and triangular clay crucibles for refining and gold-beater's use. Also muffle furnaces and flint glass crucibles.

B. Looker, of Kingston-on-Thames, exhibits horticultural appliances of earthen-ware and glass, without putty, cheaper much than wooden frames, lead, or bell glasses, more durable and portable, and retaining more heat. The glass covering is held in its place by grooves in the brick, top and bottom, easily removed and ventilated ; it is adaptable to the growth of early vegetables, strawberries in borders, and forcing grapes. Growers all prefer for ripening fruit a double roof to a lean-to.

W. E. Rendle has an arrangement like Looker's, which has the advantage that the pit may be easily raised.

The Farnley Works, near Leeds, exhibit gas retorts of ribbed fire-clay, and glazed bricks of excellent material.

These bricks are either salt-glazed, or the face is dipped in a white "slip," and a transparent or opaque enamel glaze is added, as for majolica, all in one firing. The white body glaze does not always adhere well. These glazed bricks are well adapted for lining the walls of dark courts that require lighting, and for shops, closets, &c., which require a material easily kept clean.

R. N. Norman, Hurtspierpoint, bricks of deep plum color, well modelled.

E. C. Gibbon's, Ipswich, red and white ornamental bricks and tiles are much used.

Fareham red brick. This brick is easily cut and rubbed and has high qualities of finish and color. A window of rub-bricks shown by Wm. Cawte, is well executed; but rubbing or cutting bricks, and in general all fire-clay goods, is highly injurious to their durability, as it removes the hard non-absorbent and semi-vitrified surface.

Davison, of Egton, Yorkshire, shows good terra-cotta bricks stained.

Geo. Gunton, of Corsey Brickfield, Norwich, exhibits red, white and moulded bricks of good color and well fired. Texture somewhat sandy.

V. Laigneaux, Mons, Belgium.—Silicious fire-brick, at $5.50 per thousand.

Steam Brick Co., Reading, and Alexandra Brickworks, Suffolk, exhibit excellent moulded work in red and buff clay.

Thos. Peake's terro-metallic clay, Tunstall, Staffordshire, for roofing, ridge tiles, floor tiles, consists of fire-clay charged with as much iron as it will hold, and burnt at a high vitrifying temperature.

Broomhall Tile and Brick Co., Blackfriars, London, make tiles of a peculiar shape to form a face to concrete walls. These tiles possess an appendage which beds into the concrete while the wall is being built.

Heaton, Butler & Co.—Art tiles; figures in outline, fairy tales, lightly sketched on a white ground and successful in effect.

Maw & Co., Broseley, Salop.—Architectural majolica.

Tiles with raised pattern and colored enamels. Their patterns are good.

GEORGE JONES, Stoke-on-Trent.—Earthen-ware and majolica vases, price, $10 to $60; well executed and highly glazed.

MINTON & Co., Stoke-on-Trent.—Majolica garden flower-pots, $70 to $250. This firm makes every variety of earthen-ware except tiles, and is referred to elsewhere.

JOSIAH WEDGWOOD & SONS, Stoke-on-Trent.—Majolica vases. Already noticed.

MINTON, HOLLINS & Co., Stoke-on-Trent.—Tile works. Many patterns, raised or gilt, or in clays of two colors.

ROBERT MINTON TAYLOR, Fenton.—Variety of tiles.

MACHINERY IN THE POTTERY ANNEXE.

To exhibit in this building the machinery of all descriptions employed in the manufacture of every kind of pottery, required more space and time than could be afforded at the first of the series of Annual Exhibitions.

The following machines which were shown at work attracted considerable attention :

CLAYTON'S improved three-process brick-making machine.

CLAYTON'S double chamber hand-power brick press.

CLAYTON'S hand-power lever brick-pressing machine.

CLAYTON'S self-delivery brick-cutting apparatus.

CLAYTON'S screw-construction ornamental tile press.

LARGE'S semi-dry moulding and pressing machine.

Potter's wheel by DOULTON & WATTS.

BLAKE'S crusher (for pottery and clay, price £40, by H. R. Marsden).

Process of making tesseræ and tiles (by MINTON, HOLLINS & Co.

POLLOCK'S brick-making machine.

CAMROUX'S stone-crusher (for clay, &c., for potters).

NEEDHAM & KITE'S filter-press (used by potters to extract water from the slip and reduce it to clay).

E. Page's drain-pipe, brick and tile machine.

J. D. Pinfold's brick-making machines, with self-acting feed and cutter, price £155, and with hand feed and cutter, price £55.

Wm. Boulton's patent potter's wheel.

Wm. Boulton's jigger for moulding.

Malkin Edge's encaustic tile-press.

R. Bewley's machine for grinding colors for pottery.

J. Johnson's crusher (for flints, &c., for potters).

G. H. Goodman's crusher (a model of), for flints, &c., for potters.

Also models of patent kilns and drying-rooms, by Clayton, John Knowles, Morand, and Hoffman.

The above machinery is driven by two engines, viz.:

Manning, Wardle & Co., of Leeds, portable engine, and

Tangye Bros. & Holman's engine.

BRICK-MAKING, DRAIN-PIPE, AND TILE MACHINES.

The points upon which the three principal brick-machines of Pinfold, Clayton, and Pollock agree, are worthy of note.

As to the state in which the clay is worked, the plastic is preferred. In this condition the clay is drier than for hand labor. The working of clay in a dry state, besides requiring more power, is only suitable to clays which partially vitrify in firing, and even then the edges are brittle and crumbly.

The clay is first thrown into a hopper, containing either one or two shafts revolving in opposite directions, provided with a series of knives and scrapers arranged to form sections of a screw. In this hopper the clay is cut and mixed while it is being driven forward to a pair of smooth horizontal rollers, placed either one above the other (as in Pinfold's, a quarter of an inch apart, with cheeks to guide the clay, and through which water passes to lubricate it), or side by side (as in Clayton's, the interval being regulated by shifting the bearings of one of them by means of set screws), which effectually crush the lumps of clay.

From the rollers the clay passes into the pug cylinder, which has a central rotating shaft provided with pug knives, by which the clay is cut, turned over, and pugged while being carried forward. (In Pinfold's machine there is simply a compressing chamber here.)

So far the machines are alike in principle. But the clay which has been prepared by crushing and pugging, is susceptible of two different treatments, in order to shape it into bricks. The "compressive" and the "expressing" principle have each their advocates.

The older method of compression, which was first suggested by the ordinary hand process, consists in compressing the clay, with a piston, into metal moulds arranged in a sliding or rotating table, expelling it from the mould and pushing it on to a delivery apparatus.

The more recent method of expression, which required more thought for its invention, consists in expressing the clay in a continuous stream, through an orifice shaped like the cross-section of the required brick, and on to a travelling band, where the operation is completed by cutting the bar of clay across into separate and complete bricks. This method is superior to the other, in requiring less cumbrous and complex machinery and less motive power. The motion being continuous is not abrupt or concussive, and avoids the consequent strains and breakages, and the production is more rapid. Finally, by rolling, the air is expelled from the clay, while compression tends to force it in, causing bricks to blister, crack, and fly in firing.

Pollock's machine (Leeds) is on the compressive principle. The clay prepared in the machine, is delivered into moulds arranged in a revolving table, and compressed by a simultaneous movement of top and bottom plates, connected directly to a steam piston. The bricks are pushed on to a delivery table, and passed under a rotary brush. The lubrication of the moulds with oil is self-acting from an oil cistern cast in the frame work of the machine. The moving parts which work against the clay and the shafts are of steel.

The whole is compact and massive. Production, 9,000 bricks in 10 hours.

PINFOLD'S Machine (Rugby) is on the expressing principle; from the compressing chamber, already spoken of, the clay issues through a die or mould on to an endless travelling band, carried over rollers. Water issues in a thin film from the sides and corners of the mould near its mouth and lubricates the clay to produce a smooth surface. The stream of clay is cut while in motion by thin piano wire tightly stretched along the radii of a wheel. This wheel has a central bearing, but it is kept in position by three friction pulleys on its inner rim. The wires are guided obliquely across the moving clay, so as to cut the bricks square. By changing the mould and using cone bars the machine will make perforated bricks, coping, cornices, etc. The bricks are stiff enough to be walled at once—6 high, for drying. Production, 15,000 to 20,000 bricks; price £155. The machine is commendable for its simplicity; it obtained a medal at Oxford in 1870.

Pinfold exhibits a smaller machine, in which the bricks are cut by hand with wires. Production, 10,000 bricks, or 16,000 drain pipes per day; price £55.

In CLAYTON'S Machine (Harrow Road, London), as previously described, the clay is crushed and pugged. A piston expresses the clay through a moulding orifice or patent rotary orifice dies, and lubrication with water produces clean edges on the bar of clay. A similar stream of clay issues intermittently from the opposite side of the machine, and while one stream is in motion the other is at rest and being cut by steel wires into separate bricks. All shapes of bricks and drain pipes can be made. The bricks are strong. Production, 20,000 to 30,000 bricks per day, with 16 horse-power; price £330. Medals at all the Exhibitions.

Clayton's Double-chamber Hand-power Brick-press.—This machine, also on the expressing principle, is one of the most practical on exhibition, and consists of two compression chambers, in which the prepared clay is introduced, and two pistons acting alternately press the clay out through lubricating dies. The brick, tiles, or drain pipes are then cut with a wire; the machine stands on four wheels; one man works it by a crank. Production, 5,000 bricks per day; price £28.

Clayton's Hand-power Lever Brick-press, also portable, stands upon a barrow carriage. The principle is that of compression, the brick being first roughly made, then placed in the press-box of the machine and pressed by means of a powerful lever and cam motion, which also empties the mould and delivers the brick in a highly finished state, and more salable than hand-mould bricks. The piston is self-lubricating; one man and a boy can make 5,000 bricks per day; price £17 to £25.

Clayton's Self-delivery Brick-cutting Apparatus is intended to be applied to any machine working on the expressing principle, even those in which the motion of the bar of clay is continuous, and consequently not arrested long enough to allow the bricks to be cut. This is effected by severing a certain length (say for 10 bricks) of the stream of clay, drawing it forward and then cutting it by a number of parallel wires tightly stretched on a sliding frame. This movement also removes the plate on which the bricks rested, and substitutes a board, upon which the bricks are then removed to the drying ground; any length can be cut. The machine works accurately; price £20.

Large's Semi-dry Moulding and Pressing Machine, manufactured by Clayton, for making bricks or blocks of concrete or fire-clay. The machine is driven by steam. The bricks are compressed by a plunger in a movable mould, which is slid forward and emptied by a second plunger; price £80.

E. Page's Brick Drain-pipe and Tile Machine (Bedford). This is also one of the most practical machines exhibited, as it produces brick, tile, etc., by the expressing method; is worked by hand-power (one man at a crank), and is set on 4 wheels. The clay being prepared, *i. e.*, crushed and pugged, it is put by hand into a compression chamber, possessing a lubricated die orifice, through which a piston drives the brick or drain pipe on to a cutting table, where it is cut by wires. Production, 2,500 brick or 6,500 two-inch drain-pipe per day; price £20.

Experiments made for the Commissioners of Sewers gave

26 tons as the crushing pressure of an ordinary hand-made brick, and 41 tons for bricks made by expression in a machine. The pressures to crack were respectively 13 and 16 tons.

Bawden's Brick and Tile Machine (Notting Hill, London), model on ¼ scale exhibited. This machine works by the compressive method, and the clay is pugged and moulded in a state as soft as for hand-moulded bricks. One horse will supply power for 12,000 or 15,000 bricks per day. A medal awarded; price £60.

TILE PRESSES.

The manufacture of encaustic tiles was until lately carried on by the wet method, as follows: The clay tile in a plastic condition was put under a plaster mould containing a pattern, a pressure was applied, and the plaster removed. The tile was then put in a frame and liquid colored clay poured into the pattern. After drying, the superfluous clay was scraped off and the tile burned. This method has been superseded by the dry system, in which the clay is reduced to the state of a dry powder and made slightly damp. The colored clay for the pattern is first placed in the press and forced into a device cut out in a brass plate about ¼ of an inch thick. The superfluous clay is scraped off and the device plate removed, leaving the clay in the shape of the pattern. The clay for the ground is then thrown in upon it and strongly pressed. The tile thus formed is removed and the device in colored clay is found firmly inlaid in its face. Several colored clays can be used, requiring only more care in filling the pattern.

Clayton's Screw Construction Ornamental Tile-press.—This machine, mounted on 4 wheels, operates by a vertical screw, worked by swing levers, which act on a self-lubricated piston, working in guides. It is intended for ornamental and tessellated paving and roofing tiles. Delicate devices can be impressed. Two men work the press easily; price £25 to £42.

Minion, Hollins & Co.'s Hand-press for Tesseræ and Tile.—This is a screw press also. For tesseræ a number are made at a time, in a die block, by small square punches or pistons.

Malkin, Edge & Co.'s Encaustic Tile-press consists of a screw press with heavy fly-wheel, and is of solid compact make. The momentum of the fly-wheel presses the tile and pushes it up out of the mould.

POTTER'S WHEELS.

There are two exhibitors.

Doulton & Watts, Lambeth, London, show one driven by steam power and under control of the workman's foot.

William Boulton, Burslem, Staffordshire, exhibits a patent potter's wheel, in which the velocity is varied at will, within certain limits, by transmitting the movement through two vertical friction cone pulleys which are brought in contact at various points of their height. The inclination of the spindle which accomplishes this is regulated by a lever under the potter's foot, giving different ratios of velocity, without wasting the motive power by friction, as in the ordinary belt method of varying the velocity. Mr. Boulton has also a patent jigger and a system of heating factories by exhaust steam without back pressure on the engine, which has obtained some success.

COLOR-GRINDING MACHINE.

R. Bewley, of Uttoxeter, exhibits a patent machine for grinding gold and colors used by potters for china, or for paint or printing ink, or any substance that requires to be ground very fine. As a labor-saving machine, it is of particular interest, one person at a crank handle doing the work of eight. Seven glass mullers, inserted in a frame possessing a horizontal eccentric motion, press by means of india-rubber springs, and rub against a slowly revolving horizontal glass table. The colors are placed on the table, and scrapers at the circumference prevent them from wasting over the edge. The transmission movement is simple and solid ; price £30.

CRUSHING MACHINERY.

There are four exhibitors in this specialty.

Blake's stone-breaker is too well known to require description. Testimonials give $2\frac{1}{4}$ cents per ton as the cost of breaking limestone in England, including labor, fuel, and furnishings. Is also used for emery stone. H. R. Marsden, Leeds, makes them for £75 to £350, according to weight (36 to 376 cwt.). When placed on four wheels (£5 to £15 additional), their utility is greatly increased, as it overcomes the objection of having to transport large heaps of ore to one spot.

Camroux's machine (by Gardiner & Mackintosh) operates by the continuous rotation of two angle-grooved circular discs of chilled cast iron, placed upon two shafts slightly inclined. There is a heavy fly-wheel. The machine will crush to any size, ores, quartz, granite, emery, &c.

Jas. Johnson exhibits his patent pulverizing machine. It consists of a horizontal polygonal cylinder of wood lined with iron. In the interior angles near the heads of the cylinder are fastened angular obstructions, which, when the cylinder revolves, strike against the ore or stones it contains, and, according to the testimonials, are very effective in pulverizing the materials.

G. H. Goodman, 53 Penrose-street, Walworth, London, exhibits a model of a machine for crushing clay or stones, in which the grinding is done by a heavy ram which travels loosely on an eccentric; price £40 to £120.

KILNS AND DRYING-ROOMS.

As clay becomes hard and solid, only by the application of heat, this department of pottery deserves particular study.

A great variety of kilns are used, of forms governed chiefly by habit, and which are often easy to replace by others, better adapted to the purpose, *i. e.*, which waste neither fireproof materials nor heat.

The chief progress has consisted in abandoning the square forms for oval and circular ones, in the introduction of Langen's and other grates, of chambers and flues for the use of powdered fuel and gas fuel; also in applying more fully the reverberatory principle, and finally in substituting the continuous system of firing to the previous intermittent method, wherever the amount of the production would justify its use.

Wood is considered the best fuel, and non-sulphurous gas coal the next best. Peat is also used. For the manufacture of superior wares, the products of combustion are usually not allowed to come in contact with the ware.

The flame required is a somewhat reducing one, in the case of porcelain, and highly reducing for stone-ware. Although there is loss of heat in creating a reducing flame, since oxide of carbon only is produced, yet this flame disseminates the heat with much greater uniformity than an intense oxidizing flame. It also partly reduces the oxide of iron in the clay. Transparent glazes are easily dimmed by the bituminous substances present in highly reducing flames.

There are four models of kilns exhibited:

HOFFMAN'S PATENT ANNULAR KILN, a model shown by H. Chamberlain. This kiln is on the continuous system, applied by Hoffman & Licht to a series of brick chambers forming an oval, each chamber communicating with the contiguous ones by a short direct flue, and also with a central chimney; each flue-opening is provided with a damper which can effectually close it. The products of combustion, after heating the objects in one chamber, pass to the next, and so on until it reaches a chamber containing green bricks or pottery, where they are turned off into the chimney, until the contents of this chamber are dry, when they are admitted to the next. The chambers are filled from the top through an arched roof. This oven is excellent, and its use is spreading. The saving in fuel over open kilns is 80 per cent. At the Berlin Porcelain Works, a kiln (see Hard Porcelain) is erected in which gas fuel will be used. The older oven of Gibbs & Maille, on the same principle, failed chiefly from the intricate zigzag circulation of the products of combustion. Agents in the United States, Messrs. Wedekind & Duberg, Baltimore.

Morand's Patent Kiln for Ceramic Wares.--A model by T. S. Derham.—A series of chambers communicating with each other and with a central chimney, operating also on the continuous system. There is a particular disposition of vertical flues traversing each chamber. They are intended to produce a high heat by the economical use of powdered fuel, which is dropped through them after a preliminary period of heating from a bottom fire.

John Knowles.—A model of patent kiln.—This disposition consists of three circular reverberatory kilns, placed in a triangle and communicating with each other, so as to make the operation to a certain extent continuous. The kilns are divided into chambers, provided with fire-holes at the bottom, on the outside, and an entrance into each.

Clayton & Son, London, show a patent kiln for drying bricks, by which brick-making may be carried on all the year round. Hot dry air enters the kiln at the top, passes down through the "hacks" of brick and is drawn out below by exhausting fans or otherwise. The smoke and heat of the furnace pass through the walls of the building. There are no underground flues. These kilns are cheap to build and economize space, as the bricks are piled in them in walls 6 or 8 feet high.

CONCLUSION.

It will be seen from the preceding how varied and comprehensive was the Exhibition of Pottery this year, and the more interesting for being the only one of the kind to take place, in conformity with the programme, for ten years.

The official reports which are being published in London, will be instructive and read with interest, being in every case the work of men well-known in the specialties they have undertaken.

The oportunities afforded to study the products, and to some extent the processes, must result in imparting a fresh impulse to all the departments of this industry.

In matters of taste, a preference was manifest for subdued decoration, lively but not excessive coloring, and constructive utility.

In matters of invention, the successful application to new purposes, of materials previously known, and the extended use of labor-saving machinery, attracted particular notice.

The mechanical excellence of horticultural and chemical appliances, building materials, and sanitary ware, was often remarkable.

And finally, the superior technical qualities, facility of uniform and rapid production, and great artistic merit and beauty, of many of the products in this department, deserved and received general approbation.

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