BRITISH MANUFACTURING INDUSTRIES.

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POTTERY,
By L. Arnoux, Art Director and Superintendent of Minton's Factory.

GLASS AND SILICATES,
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FURNITURE AND WOODWORK,
By J. H. Pollen, M.A., South Kensington Museum.

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PREFACE.

The object of this series is to bring into one focus the leading features and present position of the most important industries of the kingdom, so as to enable the general reader to comprehend the enormous development that has taken place within the last twenty or thirty years. It is evident that the great increase in education throughout the country has tended largely to foster a simultaneous interest in technical knowledge, as evinced by the spread of Art and Science Schools, Trade Museums, International Exhibitions, &c.; and this fact is borne out by a perusal of the daily papers, in which the prominence given to every improvement in trade or machinery attests the desire of the reading public to know more about these matters. Here, however, the difficulty commences, for the only means of acquiring this information are from handbooks to the various manufactures (which are usually too minute in detail for general instruction), from trade journals and the reports of scientific societies; and to obtain and systematize these scattered details is a labour and a tax upon time and patience which comparatively few persons care to surmount. In these volumes all these facts are gathered together and presented in as readable a form as is compatible with accuracy and a freedom from superficiality; and though they do not lay claim to being a technical guide to each industry, the names of the contributors are a sufficient guarantee that they are a reliable and standard work of reference. Great stress is laid on the progressive developments of the manufactures, and the various applications to them of the collateral arts and sciences; the history of each is truly given, while present processes and recent inventions are succinctly described.

BRITISH MANUFACTURING INDUSTRIES.

POTTERY.

By L. Arnoux, Art Director and Superintendent of Minton's Factory.

Without entering into an elaborate dissertation on the antiquity of the Art of Pottery, which would be out of place in so short an article as this, I will briefly state that the practice of making vessels from plastic clays, for holding liquids and provisions, first resulted from the exertions made by man to emerge from his primary condition. It is a well known fact that vessels of clay, only partially baked, have been found, together with stone implements belonging to prehistoric times, and that those vessels, unfinished as they were, had peculiar characteristics. But supposing that this was not so, it must strike everybody that, after providing himself with those rude instruments wherewith to obtain his food and protect his life, man must have taken advantage of his power of observation to notice the property of plastic clay to retain water, and to find out to what useful purpose it might be brought for making vessels better suited to his wants, than the skins of animals or pieces of wood roughly hollowed out. If not probable, it is however not impossible, that the first man, taking in his hand a lump of soft clay, should have tried to give it a defined shape, in which case the art of pottery would be as ancient as the human race. It may have been anterior to the use of fire, for a sound and useful pottery may be made with clay hardened in the sun, as still practised in Egypt and India. At all events, it existed previous to the working of the first metal, as one can hardly understand how bronze could have been melted, without the assistance of vessels made of fired clay carefully selected. Consequently it is admitted by everybody, that this is one of the earliest of human inventions, and that the material has proved most durable. This durability, secured by the application of heat, is a very remarkable phenomenon; for while many other materials, apparently very hard, have been found unable to stand the atmospheric changes or the continuous contact with a damp soil, it was sufficient to submit this one to a very moderate heat, to be enabled to resist these various agencies for several thousands of years. This is particularly noticeable in the black Greek pottery, which, while possessing all its former appearance, can, however, be scratched by the nail or broken by a gentle pressure between the fingers. It is thus that we are indebted to the art of pottery for innumerable works of art, many of which have proved most useful in elucidating historical facts, and making us acquainted with the habits, dresses, and ceremonies of ancient peoples.

One can understand how difficult it is to decide who were the earliest potters. It is a question that archæologists have often tried to answer, but which is not likely to be ever solved. Pottery was created to meet a special want of the human race, and we find early pottery existing in almost every part of the world, in unknown America, as well as in Europe or Asia. It is, however, easier to decide which people first excelled in it, and in this respect we must give equal credit to the Egyptians and the Chinese. It is mentioned in sacred history that more than 2000 years B.C. the Egyptian potters were celebrated for their skill, and if we can believe Chinese tradition, the manufacturers in China were at this same time under the control of a superintendent appointed by the government. Unfortunately, we have very little information respecting the history of the art in China, previous to the sixteenth century; and although we have a notion of what they did and how they did it, it is wiser, with our imperfect knowledge, to abstain from speculating as to when the different sorts of Chinese ware were produced. But as regards the Egyptians, there is no uncertainty; some of their ceramic relics bear their own inscriptions, and others have been found associated with objects or monuments whose dates have been carefully ascertained. We may well believe in their skill, when we know that they were acquainted with the most difficult processes for making the bodies and glazes, and that they used the same metallic oxides for colouring their ornaments that we are now using, though often, let us acknowledge, with less success. During a period of at least eleven hundred years, from the eighteenth to the twenty-fourth dynasty, they displayed considerable ingenuity in the production of small figures, jewellery ornaments, and hieroglyphic tablets, in which several sorts of pottery mixtures and differently coloured glazes were most cleverly associated. It is from Egypt that sound principles of pottery making seem to have spread to the different nations; first to the Phœnicians, who in their turn became famous for their knowledge in the art of vitrifying mineral substances; and then to the Assyrians, who seem to have applied pottery more specially to the ornamentation of their buildings.

Greece, who shortly after received her first notions of art from the two former nations, did not devote her energies so much to improvement of material and richness of colour, as to the refined beauty of the shape and the excellence of the painting.

In pottery, the material is of little value, and it is only by the art displayed in shaping and decorating it, that its price can be increased. In this respect the Greeks proved to what enormous value it could be raised, by making it the groundwork of their art, since sums equivalent to several thousand pounds of our money were readily paid by Roman patricians for a single Corinthian vase. In this, as in the other branches of art, the recognized taste of the Greeks will never be surpassed; and if at the present time little attention is paid by collectors to their ceramic productions, it is probably owing as much to the versatility of our tastes and fancies, as to our inability of showing the articles to their advantage.

The Greeks seem to have monopolized the ceramic production of these fine works for seven or eight centuries at the least; for although vessels of the same description were largely produced in Italy, it was invariably by the Greeks, following closely the traditions and mode of decorations of their own country. It was only about a century B.C. that the Romans began to create a pottery on which they impressed their stamp, a pottery really their own; I mean that which is so improperly called Samian, and so easily known by its reddish colour and the embossed ornaments by which it is profusely covered. It is, however, genuine and characteristic, neatly executed, and possessing some standing qualities which did not belong to the Greek. On the other hand, the refinement is deficient; the forms are derived from the circle instead of the ellipse; the plain surfaces are replaced by embossments, and the painting is absent. For four centuries, the Romans seem to have made this class of pottery in several of their European settlements, chiefly in Italy and in the provinces adjoining the Rhine. In the operation they seem to have required some special material, which imparted to its bright red surface a semi-shining lustre or glaze, and which has proved remarkably durable. After this, the art of pottery experienced a time of darkness, when all the refined processes seem to have been neglected, and primitive vessels, like those produced by the Saxons, Gauls, and Celts, ranked amongst the best examples. The decorations, if any, are rudimentary; not only is the painting reduced in a few instances to some lines or spots made of a different clay, but even the embossed ornaments are replaced by lumps of clay or impressed lines in a kind of geometrical disposition. Art was not quite dead, but it scarcely breathed. However, these specimens are not altogether uninteresting, for they were the first efforts of our forefathers, and there is always a certain pleasure in witnessing the feeblest attempts made in the research of art.

But the time came when pottery was to accomplish another revolution, no less remarkable than the first. Strangely enough, it was again from the East, in nearly the same province in which it originally took its rise, that it was revived, and it is not unlikely that some faint tradition of the old processes was the source whence sprung the new ceramic era, which was to extend to our own time.

The precise date of this revival is not positively ascertained; but it was probably contemporary with the establishment of Islamism amongst the Arabs. The energy displayed by this people in improving and adapting the different fabrics to the requirements of their new religion, was no doubt beneficial to the art of pottery, and with their fanaticism and spirit of proselytism, they carried their new ideas to every country which they conquered. Syria became a great industrial centre, and some of its towns, such as Damascus, were soon famous for the perfection of their wares. To reach Europe, however, this new movement did not take its course through Greece and Italy, as in the first instance; it was through Egypt and the North of Africa that, at the beginning of the eighth century, it made its way to Spain, where it became firmly established. As regards pottery, nowhere were better specimens produced than in the towns of Malaga, Grenada, Cordova, and others, going northwards as far as Valencia and Toledo. The newest feature of the Arabian or Saracenic pottery (called Hispano-Moresco ware, when made in Spain) was the introduction of the oxide of tin in the glaze, to render it opaque. Previous to this innovation, when white was required for a design executed on a clay which did not take that colour in firing, these parts had to be covered with a silicious mixture, and subsequently coated over with a transparent glaze. This was the Assyrian and Persian process. To find a white opaque enamel, which could be applied direct on a coloured clay and adhere firmly to it, was a great discovery.

Everyone now knows how successfully these people used pottery for the ornamentation of their buildings, and how ingeniously they mixed transparent and opaque enamels to obtain an unprecedented harmony of effect. Not only did they use this tin enamel in parts, but also all over the ware, making it more or less opaque as they wished; and this was the origin of the pottery called *majolica*, which, according to tradition, was imported from Majorca to Italy, at the beginning of the fifteenth century, and for the introduction of which credit is given to Lucca Della Robia. *Terra in-vitriata* was the first name given by this sculptor to his works, when they were coated with this opaque mixture. There was at that time such an earnest desire to find suitable materials for art decorations, that the new enamels soon ceased to be exclusively applied to architectural purposes. Under the beneficial influence of the revival of taste for ancient art, and the encouragements with which it met from the princes at that time ruling the Italian Republics, majolica attained its beauty, though its external appearance reminded us but little of its Spanish or Oriental origin. During the course of the fifteenth and sixteenth centuries, the most famous in the history of modern art, the influence of the great painters of that period was soon felt by those whom we may call the artists of pottery, for the name of potters could hardly do them justice; and several of them applied their talents to the reproduction, on that ware, of their most celebrated paintings. It was reported that Perugino, Michael Angelo, Raphael, and many others painted majolica ware, probably on account of their cartoons being often reproduced; and it is sufficient to say that such talented men as Francisco Xanto da Rovigo, Orazia Fontana, and Georgio Andreoli, devoted their energies to the improvement of this branch of art. Most of the Italian towns had their manufactory, each of them possessing a style of its own. Beginning at Caffagiolo and Deruta, they extended rapidly to Gubbio, Ferrara, and Ravenna, to be continued to Casteldurante, Rimini, Urbino, Florence, Venice, and many other places.

After the sixteenth century, majolica soon degenerated in appearance and quality, the producers being more anxious to supply the market, than to devote to their ware the care and attention bestowed on it by their predecessors. In increasing the quantity of tin in their enamel, to make it look more like porcelain, they impoverished their colours, and this alteration, however prejudicial to majolica, assisted greatly in the new transformation which it was subsequently to undergo. It was under the name of faïence that it continued to be known, and France and Holland became the principal centres of its manufacture. At Nevers, it still resembled slightly the Italian ware, though at Delft, in Holland, it was principally made to imitate the blue and white ware of the Chinese, in which attempt the makers were often remarkably successful. At Rouen, the blue ornamentation was relieved with touches of red, green, and yellow; at Moustiers, the monochrome designs were light and uncommonly elegant; at Paris, Marseilles, and many other places, the flower decoration of the old Sèvres and Dresden ware was imitated with a freedom of touch and a freshness of colour which is really charming. This pottery, which was a great favourite in the seventeenth and eighteenth centuries, declined rapidly soon after our present earthenware made its appearance; the chief inducement for the change, on the part of the manufacturers, being the excessive price of tin, which is the principal ingredient of enamel.

Except in the provinces contiguous to France, Germany was never a producer of majolica. It created, however, a pottery entirely of its own, full of originality in its general appearance, and which, by the peculiarity of the process, was really a very distinct type. I am alluding to the Flemish and German stoneware. There is a tradition, that the first pieces were made in Holland at the very beginning of the fifteenth century. The principal centre of its production was, however, in Germany, at Nuremberg, Ratisbon, Bayreuth, Mansfeld, and other places; but the best were made in the neighbourhood of the Lower Rhine, where the clays most fitted for that class of pottery were easily to be found. Here we find, for the first time in Europe, the body of the ware partly vitrified by the high temperature to which it was submitted, and also the remarkable peculiarity, that it was glazed by the volatilization of common salt, thrown into the oven when the temperature had reached its climax. The combination of these two processes had never been effected before, and it would be difficult on that account to find any connection between stoneware and some of the Egyptian potteries. This stoneware varied in colour: some were almost white, some brown, others of a light grey, the last being the most valuable when the effect was increased by blue or purple grounds, harmonizing admirably with the foundation colour of the ware. The shapes are generally elaborate, with a great many mouldings, enriched with embossed ornaments in good taste, some of which were designed by no less an artist than T. Hopfer. The decline of this stoneware began with the seventeenth century, and from that time to the present, this material was only used for wares of the commonest kind. It is only very lately, that it was revived successfully by Messrs. Doulton and Co., of Lambeth.

France, which had not as yet any ideas about the process for imitating the Italian majolica, created towards the same time two new sorts of pottery, one of which is the Palissy ware, the other the faïence d'Oiron. Palissy, a very inquisitive and intelligent man, is said to have been possessed by a strong desire to reproduce some Italian ware, which he had the opportunity of seeing; whether it was a piece of majolica or of graffito, is not known. Left to his own resources—for there was nobody to instruct him—he succeeded by perseverance and industry in finding out the process for making the different coloured glazes that the Moors had used long before him. There was no discovery in this, but the talent which he displayed in the mixing and blending of these vitreous colours, combined with the incontestable originality of his compositions, have made this ware very difficult to imitate.

The time of its production was limited to the life of Palissy, for there is not really a single good piece which can be traced to his successors. In the faïence d'Oiron, incorrectly called Henri Deux ware, we find a real cream-coloured earthenware taking precedence of two hundred years over our own. It was made between the years 1524 and 1567, and we have now every proof that three persons co-operated in this invention: Heléne de Hangest, who had been formerly entrusted by François I. with the education of his son, afterwards Henry II.; her potter at Oiron, named François Charpentier; and her secretary Jehan Bernart. The charming pieces resulting from the combination of these three intellects were few, and only intended to be offered as presents to the friends of the noble lady at court. This sufficiently explains the monograms and devices, which are found associated with the elaborate ornaments profusely spread over their surface. No ware was ever made before or after this, which required more care and delicate manipulation, and this explains why the highest prices paid in our generation for an article of pottery have been freely given for several of these curiosities. Their principal feature consists in inlaying differently coloured clays one into the other, a process not quite new, as it had been extensively used in mediæval times for making encaustic tiles for the flooring of our churches, but they were so minutely and neatly executed, and the designs so well distributed, that they are justly considered as marvels of workmanship. In speaking of these faïences d'Oiron, we can hardly admire sufficiently the variety in the productions of this period of the Renaissance; and if we select four of these specimens, such as a piece of Faenza ware, one of stoneware, one of Palissy, and another of Oiron, they may fairly stand as good illustrations of the ingenuity of man.

The progress realized in these times seems to have undergone a sort of lull, and if we accept the French and Delft faïences, which were a transformation of majolica, we find that the greatest portion of the seventeenth century was not marked by any new discovery or decided improvement. Towards its close, however, we begin to notice in Germany and the western countries of Europe several attempts at making a ware, possessing the three standard qualities of whiteness, hardness, and transparency of the Chinese, and these were the precursors of the great movement which occupied the whole of the eighteenth century. As might be expected, inquiries made in different countries by persons unacquainted with each other, brought different results; and if they failed in so much, that a porcelain identical to the Oriental was not reproduced, all of them succeeded in making a white ware of their own, adapted to the materials which they had at their disposal. And thus arose in each country the source of a prosperous trade.

It is only at that period, that England began to take her position amongst the producers of pottery, at least in a manner deserving of that name. Up to that time, if we were to judge by the quality of her work, she did not seem fitted for it, no more than for any sort of manufacture which required taste or a certain knowledge of the arts of design. In fact, it is easy to notice in looking at our collections of art manufactures, that the English samples are deficient in many respects; they may be gaudy without harmony of colour, or elaborate without refinement, exhibiting a certain amount of roughness in execution, when placed side by side with Italian, French, or German specimens of the same class. It is likely, with certain exceptions, that the Anglo-Saxon race did not feel much the want of all those niceties, and did not make great exertion to excel in the practice of those arts, for the appreciation of which its mind was not yet sufficiently cultivated. It has been remarked, that as the progress of art was constantly from East to West, the geographical position of England might account in some respects for her backwardness. However, like children of slow growth whose understanding does not seem quick or acute, but who afterwards derive the benefit of their reserved strength, England, coming almost the last in the production of pottery, seems as though she did so for maturing her capabilities. In this, as in the practice of other arts, she is slow, and her first steps are clumsy. Experimenting for some time, with mixed or indifferent success, she seems to hesitate, till she begins to feel that she holds the thing in her grasp, and then the day soon comes when she teaches the world what she can make of it. We can scarcely give her credit in the preceding review for some Staffordshire pottery made with the yellow or red marl, thickly glazed with the galena extracted from the Derbyshire mines, the decoration of these pieces being effected by pouring the light clay on the dark one in a symmetrical manner. This pottery was in use from the time of Queen Elizabeth down to the year 1775, the date of the latest specimen that I have seen. Some pieces preserved in the British Museum, in the Museum of Geology, and in M. Solon's collection, are to be noticed for their quaintness.

Up to the eighteenth century, no other clays than those extracted from the coal measures seem to have been used in Staffordshire; and the advantages derived from an abundant supply of both clay and fuel must have powerfully contributed to the settlement of this industry in that county. In Shaw's 'History of the Staffordshire Potteries,' which with Plot's 'History of Staffordshire,' are the only books to afford information on the then state of this trade, and whose most interesting extracts have been given by Sir Henry de la Beche in his excellent catalogue of the pottery exhibited in the Museum of Practical Geology, we gather this fact, that so far back as 1661, an Act of Parliament regulated the dimensions and quality of earthen vessels manufactured at Burslem, for holding the butter brought to the markets.

Towards 1680, a radical change seems to have taken place in the way of making the ware, by substituting common salt for the galena in the glazing process. This new production was called *crouch ware*, and there is every probability that the substitution was first made by a person acquainted with the manufacture of the German and Flemish stoneware, which at a former period had been tried in England. At that time Burslem possessed twenty-two ovens, and Shaw says, that when these were at work, the vapours emanating from the salt were such as to produce a dense fog in the town. These assertions leave no doubt as to the date of the commencement of this manufacture in Staffordshire, and that Burslem was its first seat.

Two German brothers, of the name of Elers, who settled near this town in 1688, seem to have been the first to try to produce pottery of a better class than the crouch ware. Their first attempt resulted in the production of a well finished red stoneware, which probably resembled the red ware made in Saxony by Bottger at the same time. Those who have left any written information about it, say that for general appearance and careful execution, it was quite equal to any similar article made by the Chinese; but I must confess, that the specimens that I had the opportunity of seeing are rather porous and far from being highly baked. These foreigners paid also great attention to the improvement of the white ware, and they were the first to employ the plastic clay from Dorsetshire for the purpose of whitening the cane marl of the locality. Their ware was generally light and well-shaped, and though the plaster moulds were wholly unknown at the time, and were only introduced fifty years later, the impressions taken from metal moulds are neat, and show the ornaments standing sharply out from the surface. This, combined with the peculiar appearance given to the surface by the sublimation of the salt, and its light colour, are the principal feature of the Burslem ware, which continued in existence till 1780, although before that date more perfected articles had found their way to the market. The brothers Elers used to make a great secret of their mixtures, and left the district as soon as the other manufacturers became acquainted with them. Astbury, who had been instrumental in robbing them of their processes, was one of the most intelligent amongst these potters, and it was he who, in 1720, introduced the flint, calcined and ground, for whitening the body of the ware, one of the greatest improvements in the making of earthenware. He seems to have been a thoughtful and persevering man, and it is said that the idea of this new material was suggested to him, by seeing a shoeing smith calcining a flint, for the purpose of blowing the dust into the eyes of his horse, suddenly afflicted with a kind of blindness. This is probably only a fiction, as the idea must have originated from witnessing the change undergone by flint when brought to a red heat.

As the pottery trade was taking root in the district, it is no wonder that we find many intelligent manufacturers doing their best to improve it and make it profitable. Eminent amongst them was Josiah Wedgwood, whose name as a potter is never likely to perish. For particulars concerning his private life, trade, and manufacture, there are two excellent books, by Miss Meteyard and Mr. Llewellyn Jewitt, in which every matter of interest about him has been carefully entered. Born at Burslem, in 1730, of a family of potters, he began by serving his apprenticeship as a thrower under his brother, and must have settled in business very early, as he had had already two partners when he set up on his own account, in 1759, being then only twenty-nine years of age. His first attempts seem to have been directed to making a green ware, that is, a white ware covered with a glaze of that colour, which he succeeded in getting particularly bright; and also to the tortoiseshell, which had its surface mottled with glazes differently stained, and which, by their blending when they are fused in the oven, present some analogy with the works of Palissy.

One of Wedgwood's decided successes was, perfecting the white cream-colour ware, which was so superior to anything done before, that it commanded at once a great sale at home and abroad. Queen Charlotte admired it much, and, in consequence of her patronage, it took the name of Queen's ware, under which it was known for a long time. It is light, of a pleasing colour, elegantly shaped, and in the hands of artists has proved an admirable material to paint upon.

It would take too long to enumerate all the improvements which Wedgwood effected in his trade in the second half of the last century, but I must mention as prominent amongst his works, the black Egyptian and jasper wares, in making which he had no assistance whatever, and which constitute two new and perfect types in pottery. From Wedgwood's origin and early labours, it is easy to guess that his instruction must have been limited; but he was a clear-minded and inquiring man, possessing that sort of intuition by which he could easily understand things, which in other people would have required preliminary studies; besides, he had a natural taste for art and a systematic way of going through his experiments, which were sure to bring them to a successful issue. It was his good fortune to be assisted by two men of superior intelligence, viz. Flaxman, the sculptor, who designed many of his shapes, and modelled for him an almost innumerable number of subjects for slabs and cameos; and Thomas Bentley, a distinguished scholar, with whom he was commercially connected, and whose knowledge of art he found of great utility.

When Wedgwood died, in 1795, the ceramic manufacture had extensively developed, and had extended from Burslem to the small towns in the neighbourhood. From all this it must appear that, although Wedgwood was the most brilliant type amongst the English potters of that period, the trade was already well established when he entered the business, and there was every probability, that it would become one of the staple industries of this country. To give all the credit to him would be an injustice to several men, who, like the two Josiah Spodes, effected great improvements, or brought into play new and useful materials.

When I speak of the china manufacture, it will be seen that, besides the Staffordshire potters, several very clever men at Bow, Chelsea, Plymouth, Worcester, Derby, and other places, were at work to establish the manufacture of the soft and hard porcelain, proving beyond a doubt, that most energetic efforts were being made to raise the pottery trade of England to the same level as that of France or Germany. If we did not then succeed in making soft china like that of Sèvres, or hard porcelain as good as the Dresden, we soon became the masters of the market as regards earthenware—a position that we are not likely to lose for many years to come. Amongst the circumstances which combine to make our position particularly strong, it is enough to mention our independence as regards the supply of the raw materials, and the abundance of our clays and fuel, of a better quality than those at the disposal of our competitors. Besides, the localization of this manufacture in Staffordshire has caused the concentration in this spot of an intelligent population, acquainted with the traditions, from which the different branches of the trade can be easily fed.

The soil of Staffordshire produces a variety of clays which are used for common ware; but the most important is the one called *marl*, which is fire-clay from the beds of the coal measures, used for making the "saggers," or clay boxes, in which the ware is placed before it is sent to the ovens. The quantity required for this purpose is very large, and it was of the utmost importance that such material should be good, cheap, and easily procured.

At present, however, the clays necessary to make china or earthenware are not found in Staffordshire, but are sent from the counties of Dorset, Devon, and the Duchy of Cornwall, where they constitute an important branch of commerce. It is a common occurrence to hear people, visiting Staffordshire for the first time, wonder at the apparently abnormal fact of an industry settling in a district where none of the requisite materials are to be found. I have mentioned in the preceding pages how it happened that the trade first settled in Burslem; and a short explanation will show that, although more perfect clays from distant counties had to be used, there was no need to change.

For baking pottery, the quantity of fuel required is comparatively large. When, independently of the ovens and kilns, we take into account what is absorbed by the steam-engines, preparation of materials, and warming of the shops, we find that for every ton of manufactured goods, at least three tons of coals are wanted, and that for decorated goods, it will take twice that quantity, and even more. As the districts from which the clays are sent have no coals, the advantage of paying the carriage on the smallest number of tons to be brought to the works becomes evident.

The potter's clay derives its origin from several felspathic rocks, which under various influences have been decomposed, and the finest portion washed away, to be collected in natural depressions of the soil, where it has formed beds of various thickness. Chemically speaking, it is a silicate of alumina in combination with water, with the addition, in small quantities, of different materials, such as potash, soda, lime, or iron, acting as fluxes on the silicate, which otherwise would give no signs of vitrification. The iron, which may exist in different states, has a colouring effect injurious to the clay, which, to be useful, must be almost free from it. When this condition occurs, the excellence of the clay is determined by the quantity of alumina that it contains. Pure silica, in the form of quartz, flint, or sand, is a very easy material to procure when wanted, but as no geological formation yields alumina in the pure state, no other can be got, besides that which already exists in the clays. It is a common error to say, that it is the silica which renders them refractory. It is true that pure silica can stand any amount of heat without fusing, but its readiness to combine with alkaline matter, and to form vitreous compounds, renders its use objectionable when heated with metallic oxides. An excess makes the wares brittle and unable to resist sudden changes of temperature, while alumina, on the contrary, gives these qualities, and with them the plasticity required for the working of the ware. From it the clays derive the property of absorbing and retaining a large quantity of water, and such is its affinity for it, that sometimes a red heat will hardly suffice to expel it completely. Alumina is a light material—silica a heavy one; and a potter ought to know approximatively in testing the density of a sample, whether it is rich or poor in either of the two. The reason why the clay deposits are richer in alumina than the rocks from which they originated, is explained by the lightness of this element, which, being kept in suspension in water for a longer time, was consequently carried farther, leaving the silicious refuse to settle on its way.

For earthenware or china, the English potters use only two sorts of clays: the ball clay, also called blue clay, and the kaolin. For porcelain the last only is used; for earthenware, both. The ball clay, exported from Teignmouth and Poole, comes from the lower tertiary clays of Devon and Dorset, and is remarkably good and plastic, the quantity of iron being comparatively very small. The ball clay from Poole is dug in the neighbourhood of Wareham, by Mr. Pike. It is of a very superior kind, and more than 70,000 tons are sent from that harbour alone to the potteries, besides smaller quantities to the Continent. As it possesses a little more alumina than those from Teignmouth, which are dug at Teigngrace and Whiteway, near Bovey Heathfield, they ought to have a little superiority over these, although in practice the difference is not always perceptible.

Kaolin is the Chinese word given to the clay from which hard porcelain is made, though here it is generally called China or Cornish clay. This material is found in some granitic rocks in an advanced state of decomposition; the felspar, their most important element, having under external influence lost the greatest portion of its alkali, and become converted into a kind of earth. By agitation in a large quantity of water it dissolves readily; the refuse, composed of quartz, mica, schorl, and undecomposed felspar, sinks by its own weight to the bottom of the tank where the liquid mixture is to run; and the finest part, which is the kaolin, is carried farther to large receptacles, where it accumulates. When these are full, the clay is removed and dried for export. In that state it is very white, and although not so plastic as the ball clay, contains a little more alumina and less iron, which accounts for its resisting much better the action of fire. It is principally obtained at St. Stephens and St. Austell, in Cornwall; Lee Moor, near Dartmoor, in Devon, and a few other places; the whole of them sending to the potteries about 130,000 tons annually.

From the same districts comes another granite, in a less advanced state of decomposition, called Cornish stone, which is used fresh from the mine without further preparation. In it the felspar retains its alkaline element, so that it can be easily melted, and is found a useful and cheap flux for the vitrification of the different mixtures. The composition of these rocks varies considerably, so that it requires constant experiments to determine in what proportion the quartz and the fusible parts stand to each other.

Flints are also largely used in the manufacture of earthenware. They are found abundantly in the chalk districts, the brown sort being considered the best. Under a moderate red heat they become white and opaque, and may be easily crushed between iron rollers. In that state they are placed in pans of water and ground by large stones of chert, till they become sufficiently divided to remain in suspension in the liquid without sinking and hardening at the bottom of the tanks, which, by the way, are called "arks." Flints are comparatively a cheap material, and their carriage to Staffordshire represents a large portion of their cost.

Such are the four materials essential for making earthenware. The respective quantities in which they are used vary in each manufactory, but the principle is always the same: the ball clay being the foundation, and flint the whitening material; but as an excess of this would make the body difficult to work, Cornish clay assists in making it whiter and less liable to break under a heavy weight or sudden changes of temperature. The Cornish stone is used in a small quantity as a flux, to render the ware more compact and of a closer texture. When the mixture of these materials is completed, the colour taken by earthenware when fired would not be a perfect white; the quantity of oxide of iron existing in the clays, however small, would be still sufficient to impart a yellowish tint, particularly after the glazing of the ware. This is counteracted by the addition of a small quantity of oxide of cobalt, the power of which over the iron, as a staining material, is such as to neutralize it completely; the result, in fact, being the same as that obtained by washerwomen, who use blue to the linen with the object of making it look white.

From the moment that the materials are extracted, to the time when the goods are perfected, the number of distinct operations to perform is so great, that I can only give a summary description of the most important. The grinding of those materials which are not already in a fine state of division is one of the most essential, for upon it depends the soundness of the ware, and without it the difficulties of workmanship would be greatly increased. It must be so perfect, that when the different components are put together in the slip state, they should mix readily and form a homogeneous compound. The grinding for the use of potters is a trade of itself; but good quality is of such importance, that the manufacturers who can afford it prefer having mills of their own. In these, the different materials are ground in water in separate pans, till they can pass freely through fine silk lawn, and are afterwards stored in distinct reservoirs, and the excess of water removed, so that a quart measure of each should weigh a determined number of ounces. As the potter knows beforehand the proportion of solid matter contained in each liquid measure, it only remains for him to count the number of quarts or gallons which must be introduced into the body of the ware. This being done, the liquid mass must be deprived of its superabundance of water. Till lately it was the custom to effect this by running the slip 10 or 12 inches thick over the surface of long kilns, paved with bricks and provided with flues underneath. The heat which was maintained in these, assisted by the porous nature of the bricks, was sufficient to bring it to the proper state of toughness; but the kilns could not be filled more than once a day, and required besides a large quantity of fuel, much of which was wasted in the form of dense smoke. Now, thanks to the new apparatus of Messrs. Needham and Kyte, the same result is obtained with great saving in space, time, and fuel.

The process is simple, and easy to manage. As soon as the final mixture is sifted, the slip is directed to a well, whence it is raised by an hydraulic pump and sent to the presses, which are composed of a variable number of large wooden frames. These are closely ribbed on both faces, and, when placed side by side in a vertical position, they leave in the middle an interval of about three-quarters of an inch in thickness. Each of these hollow compartments is lined with a sheet of strong cotton stuff, folded in such a way as to form a bag, in the middle of which a small metal fitting passes through the upper part of the frames, and forms the spring by which the slip can be admitted into the interior. When the bags are tied together, the slip is admitted into their interior and submitted to such pressure from the pump, that the water filters through the interstices of the stuff, and escapes by the small intervals left between the ribs of the frames. After allowing a sufficient time for the action of the pump, the presses are dismounted, and the solid clay is found in the middle of the bags, ready for use in the various departments.

The processes for shaping the different articles are many. For the more expeditious preparation of the wares, it was necessary that each workman should devote the whole of his time to a special branch of his art. For this reason we have several classes of potters, called according to their avocation: throwers, turners, handlers, hollow and flat ware pressers, figure and ornament makers, tile makers, modellers, mould and sagger makers, besides those who are employed in the decoration of the goods. Of all these various branches, the most attractive for those who are witnessing it for the first time, is the throwing; and it is a source of amazement for them to see how quickly, in the hands of the potter, the same lump of clay can be transformed in a variety of ways.

The potter's wheel is of great antiquity. In some Egyptian hieroglyphics from the tombs of Beni-Hassan, known to have been made during the twelfth dynasty, the different occupations of the potter are painted with great distinctness. In one of these, two potters are using the wheel for making their vessels—implying that this contrivance has been in use for something like four thousand years. The forms and proportions of the wheels may be varied without altering the principle. A spindle, finished at its lower end in the form of a pointed pivot, is placed on a hard substance on which it can easily revolve. The upper end is furnished with a wooden head or small platform, on which the lump of clay is to be placed, and between this head and pivot is fixed an horizontal wooden disc of large diameter, which acts as a fly-wheel and keeps the spindle in motion for a certain length of time. The motion may be given by the hand, the foot, or mechanical power, which causes the spindle to revolve with great velocity. A good thrower requires a great deal of practice, as he is expected to throw several hundred pieces a day, although the art is far from being what it was in the olden times. In consequence of the new plan of pressing all large pieces in plaster moulds, the thrower has but small or moderate size pieces to work, and these he finishes only in the inside, leaving the outside to be done by the turner, when the pieces are in a more advanced state of dryness. This division of work, brought about by the exigencies of the trade, is very much to be regretted, for the old thrower was really an artist, who could impress his feeling on the work which was entrusted to him from beginning to end. He has not now the same opportunity of showing his skill, and cannot take in his work the pride and interest which he would have felt, if circumstances had not been altered. The same may be said of the turner, who finishes the outside on a lathe like that used for turning wood. The thrower prepares the pieces of a thicker bulk than is required, and it is the turner's business to bring them to a proper thickness, by removing the excess of material and giving to the exterior a smooth and highly finished surface. If the handles are ornamented, they are pressed in plaster moulds; if plain, they are squeezed from a brass cylinder, filled with clay, with a small aperture at the bottom, from which it escapes under the pressure in long ribbons. These are placed side by side on a board, cut across at the required length, and bent in the form of handles when they get sufficiently hard. They are afterwards fitted, and made to adhere to the pieces by means of a little water or slip dropped from the point of a brush.

Flat pieces, such as plates, dishes, saucers, and the like, are made in plaster moulds, on which a bat of soft clay is tightly compressed by a hand tool, called a polisher. The process is very expeditious, although the presser is obliged to repeat the operation, to give more pressure and finish. For this kind of ware, the potter's wheel called a jigger, is simplified so far, that the iron spindle resting on its point and fixed to a bench, is provided only with a round plaster head on which the moulds are placed. The presser keeps this in motion with his left hand, whilst with the right he guides the polisher.

In those manufactories which have adopted the latest improvements, the jiggers are worked by steam power, and the stoves in which the pieces are sent to dry are heated by steam pipes. These are constructed on a new principle, consisting of a number of shelves which revolve round a central spindle, so that by a gentle push of the hand, each section is successively brought in front of the door, giving the opportunity of removing or putting in the moulds. This simple contrivance does away with the necessity for the assistant boy entering the stove, and feeling the bad effects of the heat.

When the pieces are not exactly round, and cannot be thrown or pressed on jiggers, it is the custom to have them made in plaster moulds, which have been cast on models prepared for the purpose. As long as the clay keeps soft, it takes the shape of any hard substance against which it is pressed, and for that reason, plaster, which has the property of absorbing moisture readily, is preferred. The use of plaster for moulds is comparatively recent, and although its properties were known in early times, there is no evidence that it was ever employed for that object. Greeks, Etruscans, and Romans, had their moulds made of fired clay; the Chinese, in raw clay thoroughly dried. In Staffordshire, before the use of plaster, they were made of fired clay or metal; but plaster is more economical than any of these, although moulds made of this material do not last long, and require constant renewing.

The making of moulds, well adapted for pressing the various shapes, is a very important part of the potter's business. They must allow of a certain amount of contraction, and, at the same time, must easily dislocate without pulling away any part of the piece, which is still sufficiently soft to be distorted by careless handling. Some pieces will require moulds made in one or two parts;

others, a large quantity of them, the various fragments being in that case pressed separately, and carefully put together afterwards. The pressing is done in this way: the potter begins to flatten a lump of clay in the form of a bat, and transfers it to the inside of the mould; then, by the repeated blows of a sponge in his right hand, he compels the soft material to take the exact form of the mould, and, of course, of any ornamentation which may be on its inner surface. A good presser ought to be systematic in his work, and not to apply more pressure to one part than to another, otherwise the different portions of the pieces would not contract alike, and would be liable to show an irregular surface, or even crack in the drying or firing processes.

For several reasons, there are pieces which cannot be pressed: they may be required very thin, or their shape is such, that the potter cannot reach all the parts to take the impression conveniently. In this case he must adopt the following plan. The mould is tied up, and filled with liquid clay through an opening left in the top. The plaster rapidly absorbs the water, and a deposit of solid clay adheres to the surface. This soon increases in thickness; and when the potter thinks it is sufficient, he pours out the slip which is in excess. The piece soon hardens, and when it begins to contract, it is then time to remove it from the mould. This process has the advantage of giving a uniform thickness, and as there is no other pressure than that caused by the absorption of the plaster surface, there is a better chance for the piece to contract equally, and on this account this method (called *casting*) is preferred for articles which require a neat execution. In some cases it is cheaper than ordinary pressing; but the drawback is, the excessive contraction or diminution of bulk to which the ware thus made is subjected. An irregular contraction is the source of most of the defects attending the ceramic manufacture, and it is worth explaining the causes, of which there are three. I have already mentioned that natural clays, which have remained in a damp soil for ages, contain materials in a hydrous state, i.e. combined with water, which sometimes increases their bulk considerably. These are unstable compounds, and may be destroyed by thoroughly drying them. Some other materials used in pottery may be artificially combined with water, as would be the case, if ground in it for an unnecessary length of time. The second reason is, the interposition of the uncombined water between the solid particles of the clay, and as this cannot be worked without it, this cause of shrinking cannot be avoided. It will be easily understood, that when the water in the mixture evaporates, the solid particles, under atmospheric pressure, will move to take its place, and this effect will continue as long as they find enough moisture to assist in their free motion. The consequence is, that the mass shrinks more and more, till the contraction is stopped by the inability of the particles to move farther; and this happens before the pieces are completely dry. From that state to complete dryness, the evaporation of the remaining water will leave small holes, which will make the texture of the ware porous, and prone to absorb any liquid with which it may come in contact.

The shrinkage in the raw state then is mechanical, and distinct from that which takes place in the oven under the influence of heat. Under this agency the particles enter into combination, and if the process is carried far enough, the ware may become partially vitrified and acquire a certain amount of transparency. The more perfect the vitrification, the closer will be the contact of the particles, and consequently the greater the diminution of bulk. From these causes, the total contraction may vary from one-sixteenth to one-fifth of the original model. The least will belong to ware pressed with stiff clay gently fired; the greatest, to that cast with liquid slip and brought to the vitrified state. In these last, the shrinkage is greater in height than in width, a fact explained by the weight of the upper portions acting vertically to assist the closer contact of the particles in the under-structure, when the same opposes their free action in an horizontal direction. In making the models, care should be taken to bring the contraction to a common centre, or if there are several, to strengthen sufficiently the connecting parts.

After the drying of the ware, the next operation consists in placing it in saggers, which, as I have said, are made of common fire-clay, and of a form and size to suit the different articles which they are intended to hold. A certain thickness of flint or sand is placed at their bottom for the purpose of giving them a firm bed, and as it is the interest of the manufacturer to make the same firing answer for the greatest quantity of goods, care is taken to fill the saggers as far as is safe. The placing of the ware is done at the outside of the ovens, and when these are to be filled, the saggers are quickly arranged one over the other in columns, called "bungs," each sagger forming the cover for the one immediately underneath. A small roll of soft clay placed between makes them stand better, and at the same time prevents the ashes carried by the draught from finding their way into the interior, and damaging the contents.

In ancient times, the ovens, intended to hold few pieces, were very small; but as the potters became more experienced, the sizes were gradually increased, and now-a-days some of them are not less than 19 feet in diameter. The quality of fuel had, of course, a great deal to do with their mode of construction. Now, however, that coals are acknowledged to contain more heat, and to be cheaper than wood, the ovens are generally built in a cylindrical form, with several mouths or feeders disposed at equal distances on the outer circumference, the upper part being covered by a semi-spherical dome or vault, to keep the heat inside and reverberate it downwards. This construction is very simple, the only complication being in the arrangement of flues under the bottom of the oven, so as to throw into that part a portion of the heat, which otherwise would be liable to accumulate towards the top.

The firing must be conducted very slowly at first, to prevent a too sudden evaporation of the damp, which would cause the splitting of the goods. This being done, the heat is raised gradually, care being taken to feed the mouths with fuel as quickly as it is consumed. It requires an experienced fireman, to see that one part of the oven does not get in advance of the other. He manages this by throwing in a certain quantity of air through small openings in the brick-work, which are shut or left open according to circumstances. Whatever may be the construction of the oven, the quantity of air mixed with the gas produced by the combustion of fuel causes the atmosphere to be reductive of oxidizing; which means that the different materials submitted to the heat would, in consequence of an abundance of carbon, have a tendency to be deprived of their oxygen and return to a metallic state, or that by firing in presence of an excess of air or carbonic acid, they would be kept in a high state of oxidation. It is fortunate that all classes of English pottery, without exception, require, or are not injured by, an oxidizing fire, which is the most economical way of firing, since by it all the gases are completely burnt inside the oven without any waste of fuel. By a better application of this principle, Messrs. Minton have introduced a new oven, in which the fuel is so completely utilized, that it requires only one half of the usual quantity of coals, besides doing away with the dense smoke, which is the annoyance of the district.

By the first fire to which it is exposed, the ware is converted into what is termed, from the French, *biscuit*—an incorrect name, as it seems to imply that it has already been fired twice, when, in fact, it has been only fired once. Some classes of pottery do not require more than a single firing, as, for instance, the common terra cotta and stoneware. However, for all our English ware it is necessary to have two fires, for the following reasons: First, the necessity for getting a denser texture of the ware by submitting it to a strong heat, lest the glazes which are to be melted on their surface, and which thereby become very dense and most contractible, should not agree with the more open texture of the body, and should crack or craze when exposed to changes of temperature. Secondly, that for coating the ware with the glaze, it is necessary to dip the article in the vitreous mixture finely ground, and kept in suspension in water; consequently, if it were in the raw state when this was done, the adhesion of the particles would be so small, that they would readily dissolve in the liquid. It is customary, therefore, to expose the goods first to a hard fire, which, according to the size of the ovens and the quality of the ware, may last from forty to fifty hours.

From the biscuit oven, the goods, if they are to be left white, may be sent to be glazed; but if they are to be decorated with a printed pattern, they must be forwarded to the printing department. Printing on pottery is comparatively a modern invention, its chief advantage being the cheap rate of production. Up to the last century, the goods were always painted by hand: a slow, but it must be confessed, a more artistic process, as the work executed in this way, even of an inferior kind, will exhibit a freedom of touch and facility of execution, which will make it attractive and preferable to the formality of a printed pattern, however rich or complicated it may be. This superiority is sufficiently illustrated by comparing monochrome patterns of Italian majolica, Delft, and Chinese, with the modern printed ware of the same colour.

Public taste has so wonderfully improved lately, that, for my part, I have no doubt that we shall soon have a special class of artists trained to execute, by hand, cheap and simple decorations for those purchasers who are not satisfied with printed decoration.

To what extent the introduction of printing on pottery has hindered the progress of art education in Staffordshire, is a question on which people may entertain different opinions; but we might ask, what amount of artistic work we might not do, if at the present time we had some hundreds of artisans trained from their early years to that style of painting? However that may be, the process of transferring printed patterns to biscuit ware was considered a great step, and one which contributed largely to the extension of the earthenware trade.

Liverpool and Worcester claim the priority for this invention, towards the year 1752. It is a fact that shortly after that date, Staffordshire potters used to send their wares to Messrs. Sadler and Guy-Green, of Liverpool, to be printed; and there is also every reason to believe that about the same time it was introduced at the Worcester works, then under the management of Dr. Wall, by an engraver named Hancock.

The process of printing on pottery does not differ very materially from that used for transferring to paper a design from an ordinary copper-plate. There are, however, these differences, that a metallic colour is used instead of lampblack, and that a fine tissue paper is specially made for that purpose. When that paper, with the pattern printed upon it, is laid on the ware, face downwards, the colours adhere strongly to the biscuit, which, being porous and aluminous, has a great affinity for the oil with which they have been mixed. After rubbing the back of the print with a roll of flannel, to secure the adhesion of every portion of the pattern, the biscuit piece is plunged in water, and the paper comes off quite freely, the whole of the colour sticking fast to the ware.

Previous to glazing, the printed ware must be brought to a red heat, for the sole object of burning the oil mixed with the colour. This is done in kilns, called *hardening-on kilns*.

The colours in use for printing under the glaze are not many; as few only of the preparations made with metallic oxides can, when brought to a red heat, stand the action of the glazes under which they are laid. Most of them in this case will be dissolved and considerably weakened, if they do not even completely disappear. Cobalt, and the preparations made from chromates, are the most resisting, and, when well prepared, the glaze in melting over them will bring out the colour with increased beauty.

The necessity for covering the biscuit with glaze to stop the absorption of liquids or greasy substances, which would find their way into its interior and would stain it, is so obvious, that I do not think it necessary to dwell on the importance of this operation. I have stated already that it was used by the Egyptians and Assyrians, who knew most of the saline mixtures by which white and coloured glazes could be obtained; but these, which for the greatest part were alkaline silicates, could not have resisted the action of time as they have done, if a certain amount of silicate of lead had not made them permanent. They found this material in the sulphide of lead, which by the silica it contains, or that which it meets on the body of the ware, gives a glaze, which stands exposure to damp better than any other. That this mineral was used in remote antiquity, proofs are numerous. I recollect, amongst others, some small shalti, or sepulchral figures, made in Egypt more than two thousand years ago, of which the red parts, such as the faces and hands, have been glazed in this way. My opinion is, that it was used by the Greeks, in connection with the black oxide of iron, to produce the black colour used in the decoration of their vases, and it might some day prove that it was an indispensable material in the preparation of the red smear, which is the characteristic feature of the Samian ware. At all events it is with this single material, stained with metallic oxides, that the Arabs glazed their rich-looking pottery, and the same was used afterwards for our encaustic tiles and our common pottery, from the time of Elizabeth down to the middle of the last century. Lately, however, the science of making glazes has considerably improved, and a variety of new substances have been introduced. To prepare a glaze is one of the most delicate operations possible, and failures are attended with most serious consequences. The conditions to be fulfilled are many. It must not be too fusible nor too hard, either of which conditions would make it dull or apt to craze; and it must be transparent, otherwise the colours underneath would not be clear. It may happen that a glaze which apparently seems good when it comes out from the oven, will craze when a few months, or perhaps years, have elapsed. Generally, the less alumina that there is in the biscuit, the easier is the adaptation of the glaze, and this accounts for the soft porcelains being easier to manage in this respect than ordinary earthenwares.

The materials used for the *foundation* of glazes are in principle the same as those for the body, viz. silica, in the form of flint, or sand and felspar, pure or mixed with other components in the granitic rocks, called Cornish stone. These are the hard materials to be vitrified by the fluxes, which are carbonate or oxide of lead, boracic acid or borax, potash or soda, carbonate of lime or barytes. There is no definite receipt for mixing, and they may be combined in a variety of ways. Every manufacturer has receipts of his own, and I must say that some make their glazes a great deal better than others. They are rather expensive, chiefly owing to the increased price of borax, a material of comparatively modern use, which, being apt to promote the brilliancy of the wares and the beauty of the various colours, is now extensively used. When the components of the glazes are not soluble in water, it may be sufficient to have them finely ground in water. But if any soluble salt, such as borax, nitre, or soda, is employed, it is necessary to render them insoluble, by vitrifying them together with other substances. This may be effected in crucibles, or, still better, in reverberatory furnaces, where a large quantity may be melted more conveniently. In this case, when the mass is well liquefied by the intensity of the heat, it is run into cold water, which, cooling it suddenly, causes it to break into small fragments. This is called a *fritt*; and when it is sent to the mill, any other insoluble material may be added to it if necessary. To lay a thin coat of glaze on the surface of earthenware, is a most expeditious process. Advantage is taken of the porous nature of the biscuit, which, being dipped in the liquid slip, rapidly absorbs the water, while the solid particles of the glaze, which, however fine, could not follow the water to its interior, are found coating the surface. As the pieces are removed from this bath before the pores of the clay are saturated with water, they are seen to dry almost directly.

After this, the last operation consists in firing the pieces a second time, to give them that neat and finished look which belongs to glazed substances. The saggers, ovens, and the mode of conducting the fire do not differ in this case from those used for making biscuit. The ovens are, however, smaller, and the saggers cannot be packed so closely with the different articles, as every piece has to be isolated, otherwise the glaze in melting would cause them to stick together. To provide against this, small implements made of clay cut in different forms are used, and, not to disfigure the ware, are contrived in such a way that the points of contact between them and the pieces should be as small as possible. This second firing does not take more than fifteen or eighteen hours, and this completes the series of operations, by which ordinary earthenware sold in the white or printed state may be produced. The reader must understand that the majority of these processes are also applicable to the manufacture of china, or any other glazed pottery, with some modifications which I shall take the opportunity of noticing, when speaking of these varieties.

Pottery may be decorated in a great number of ways, and the operations are so varied that I cannot describe them all intelligibly, should I attempt to do so in my limited space. I shall consequently speak only of the paintings executed on the surface. This necessitates the use of colours specially prepared and made from two distinct materials; the bases and the fluxes. The bases are generally metallic oxides or highly oxidized compounds; the fluxes are vitreous substances, similar to the glazes, but softer, whose function is, to fix the colours permanently on the ware. When both, after being intimately ground together, are fired at a moderate heat on the article, the fluxes will cause the colour of the bases to look more vigorous and brighter, the effect being rather similar to that of an oil or transparent varnish on ordinary body colour. For this object, they must have very little chemical action, and be sufficiently soft to act in a moderate quantity. If, by carelessness or accident, the temperature is raised to a degree higher than the one exactly required, new compounds are formed, and the alteration of the colour is the consequence. There are some instances in which no fluxes are required; this is the case, when the ware has been coated with a glaze sufficiently fusible to allow the bases to sink in it, as soon as it begins to soften under the influence of heat. By this process more force and effect are obtained. It is, however, seldom used, for this reason, that from the care and attention which it requires in the superintendence of the firing, the manufacturer would run greater risks, and, being unable to use large ovens, would not turn out the same quantity of ware. Altogether it is a very expensive process.

Modern chemistry has placed at the disposal of colour makers new compounds which have made the preparation of fluxes comparatively easy. At the present time two classes are required: those in which the oxides of lead predominate, and those chiefly made with borax, which on account of its great purity is used in almost every flux, and is of great service for those colours which, like the pinks and purples, would suffer from the presence of lead.

The preparation of painting colours is a little more complicated, and each requires a different treatment. The number of those found in the trade is rather large, and each artist has his favourite maker. In this, as in any other kind of painting, beginners are apt to think that they will be assisted by the use of a great variety of tints, when they will learn by more experience, that a very limited number is sufficient. I cannot undertake to give any receipts for those who might wish to prepare these themselves; I only mention the name of the substances necessary to secure each of the essential colours.

White is not a colour, but when wanted on a coloured body, it is procured by an enamel prepared with the oxide of tin. Light yellow requires the oxides of lead and antimony. Orange will require the same, with an addition of deutoxide of iron. The hydrate of peroxide of the same metal will give a golden buff. The subchromate of lead gives a very bright red, but it is very unsafe and mixes badly; the reds made by calcining the common sulphate of iron are preferred. From this, according to the degree of fire, all shades of red may be got, from an orange red to a deep purple brown. The pinks, purples, and crimsons are made from the precipitate of cassius; this is obtained by pouring a weak solution of tin in the chloride of gold. The dark blue is a triple silicate of cobalt, which, by the admixture of the white oxide of zinc, may be converted into a brighter blue. The green oxide of chrome is the base of all greens, the tint of which is modified by cobalt for the blue greens, and antimony for the yellow greens. The chromate of iron, a mineral coming in large quantities from South America, is the base of all browns. The black may be got from the mixture of various oxides, but the best is that made from the oxide of iridium. Besides the above, there is another class of colours in which the oxides are thoroughly combined with the fluxes, such as the greens made from copper and the transparent blues, which are ground colours, and must be classified with the glazes. When painting colours are fired with their respective fluxes, they are very permanent, and will not only resist ordinary atmospheric influences, but also the action of every gas or mineral acid (the fluoric excepted). This seems an advantage in favour of painting on pottery, and one which ought to give them an additional value; in reality, however, artistic merit ranks above all other considerations, and unless the work is original, connoisseurs in pottery will hardly take this into account.

Several oils possessing drying properties, such as those of lavender, aniseed, or turpentine, are mixed with the colours, which, from the fact of containing vitreous substances, would work badly; even with their assistance, it requires a certain amount of skill to master the process. We must not make too much, however, of this difficulty, generally exaggerated by the ignorance of apprentices in what constitutes the very principles of their profession. When parents, in perfect ignorance of the abilities of their son, have decided, after putting their heads together, that he shall be a painter, sometimes for no other consideration than that they can get him admission into a porcelain manufactory, or that this is the nearest to their home, the boy has not the least notion of what is before him, and hardly knows that he will have to learn that very difficult thing, drawing. No wonder then, if his deficiency in this will not allow him to produce, we will not say good, but saleable paintings, unless he has spent a dozen years on his trial. On the contrary, to one well prepared by the study of art—one who, before he sets to his work, has a clear conception of the effect which he wishes to produce—the process will not stand in the way, and he will master it in the course of a few weeks.

To induce talented men to devote their time to the decoration of pottery, is perhaps the greatest difficulty met with by our leading manufacturers. As long as the making of the ware only was concerned, they had to call for the assistance of practical men, such as potters, chemists, or engineers, the number of whom is fortunately great in England, and whose services can be secured by money. The same thing is not so easy in the matter of art. Up to a recent date, painting on pottery was not considered as the high road to fortune, and artists preferred to try their chance in oil or water-colour painting, fully aware that they would have to fight against an army of competitors, and to be satisfied with very small incomes, unless, by their, then problematic, genius, they could cut their way to the front. Since, however, the rage (there is no other word for it) for well decorated pottery has spread in almost every class of society, the prices paid for good work are more remunerative, and artists like Solon, Mussill, and Coleman, can make artistic pottery their special business.

Royal Academicians like Poynter and Marks have thought it not beneath them to prepare cartoons for Minton, and it is probable that others would follow in the same path if, with the assistance of our chief potters, they could be initiated into some of the mysteries of the craft. No doubt they would find the study attractive, and there is no fear that, having once begun, they would not keep faithfully to it. For myself, I know of no such example.

In addition to the painting colours, there are a few metals which are used to enrich pottery; unfortunately, the number of those which can undergo exposure to a red heat without oxidizing is very limited. There are only three, viz. gold, silver, and platinum, which can stand it, and, among these, silver is of little use, on account of its proneness to tarnish under the action of sulphurous gases. Gold, on the contrary, affords to the decorator one of his greatest resources. We cannot say when the Chinese began to use it; we only know that in Europe it was thought a great discovery, when, in the sixteenth century, it was used in the Italian majolica. From that time to the introduction of hard and soft porcelain in Europe, it was rarely and sparingly used; and it was at Meyssen, soon followed by the other continental and English manufactories, that they began to use it extensively. At the present time, its annual consumption by our Staffordshire potters alone represents a very large sum of money. There are several ways of preparing gold for pottery purposes; the oldest consists in grinding gold leaves on a slab, adding to it gum water, honey, or any other mucilaginous liquid. This laborious process surpasses all others; it has a very artistic effect when used thin, in the Chinese fashion, and, when laid thick, as we find it in the Old Sèvres ware, it answers beautifully for chasing; the only drawback is the expense. The most usual way is to have it amalgamated with mercury, and afterwards ground in turpentine; it has then the appearance of a blackish substance, which will regain its colour, as soon as the mercury is volatilized by the application of a gentle heat. When it comes out of the kiln, the gold is dull, and requires to be burnished with agate and bloodstone tools, to be in possession of all its brightness.

There is another decorated pottery, called lustre ware, now out of fashion, but most successfully executed at one time by the Moors, the Persians, and the Italians on their respective majolicas; the glaze of this ware being more favourable than any other for the display of the process. It simply consisted in painting over the fired ware with the protoxide of some metal, such as that of copper, taking care that from the moment the kiln began to get to the red heat, a constant supply of thick smoke should be kept up. The partial reduction of the metal which adheres to the surface has a very pleasing effect, as may be noticed in the large Hispano-Moresco dishes, considered the finest specimens of this class. Those produced in Italy by Georgio Andreoli fetch, however, a higher price, on account of the redness of their colour; the process is fully described in the celebrated manuscript of Piccolo Passo, now in the library of the South Kensington Museum. Lessore, the French painter, lately dead, and M. de Morgan, in London, have succeeded in producing very fair specimens of that kind. Some of our Staffordshire potters can make another lustre by mixing chloride of gold with lavender oil, sulphur, resin, and other carburated ingredients, and laying this mixture very thinly on the surface of the glazed ware; the iridescent pinkish colour which it takes when it is fired in an ordinary kiln is rather peculiar. This has no connection with the old process, and is only used for the commonest kind of goods.

The kilns in use for firing the painted or gilt ware, are called muffles or enamelling kilns; they are in the form of a D, laid on its straight side, and of a length proportionate to the size and number of pieces which they are to hold. The fireplaces are arranged on one of the sides, and the flues contrived in such a manner, that the flame should travel round the whole of the outer surface, great care being taken that it should not have access to the interior through any cracks or joints which might exist in the brick-work. For ordinary goods one firing may suffice; for those highly decorated, as many as five or six may be necessary.

Let me now say a few words respecting the various wares produced by our English potters.

The first earthenware made after the time of Wedgwood and Josiah Spode was far from being so good as that made at present, and several attempts were made to bring out a pottery which should be intermediate between earthenware and porcelain. The most successful was that made by Mr. Mason, of Fenton, who, in 1813, took out a patent for an ironstone china, the body of which was fluxed by the scoriæ of ironstone and the ordinary Cornish stone. But eventually this last was found sufficient for that purpose. The name of ironstone remained to that class of pottery which is strong and resistive. Since then, however, earthenware has so much improved, that ironstone has gone out of fashion; the nearest to it is the ware called *white granite*, made for the American market, which is richly glazed, and made thick to compete with the French hard porcelain, which is also exported to the United States for the same class of customers. About fifty manufactories are specially engaged in producing this ware; and those in the occupation of Messrs. Meakin, Shaw, Bishop and Powell, and G. Jones, may be considered the largest. The best earthenware is made for the home market, some of which is so perfect that, if it were not opaque, it might be mistaken for porcelain. When it is richly decorated and gilt, like that made by Messrs. Minton, Wedgwood, Furnival, Copeland, Brown-Westhead, Brownfields, and several other leaders of the trade, very high prices are obtained for it.

Some of these makers do not devote all their attention to earthenware, but produce other classes of pottery. Amongst the sorts which are most connected with earthenware are majolica, Palissy, Persian ware, and flooring and wall tiles. I have given the name of majolica to that class of ornament, whose surface is covered with opaque enamels of a great variety of colours. It is only connected with the Italian or Moorish in this respect, that the opacity of the enamels is produced by the oxide of tin; but as we have not in England the calcareous clay for making the real article, we have been obliged to adapt, as well as we could, the old processes to the materials at our disposal.

At present, English majolica is very popular, and without a rival for garden decoration, as it stands exposure to the weather better than ordinary earthenware, besides the impossibility of the latter receiving the opaque enamels without crazing or chipping.

Majolica was produced for the first time by Messrs. Minton, in 1850, and they have been for many years the only producers of this article. It is only five or six years ago that Messrs. Maw, of Broseley, in Shropshire (and very lately the Worcester manufactory), have made a pottery of the same kind. The name of majolica is now applied indiscriminately to all fancy articles of coloured pottery. When, however, it is decorated by means of coloured glazes, if these are transparent, it ought to be called Palissy ware, from the name of the great artist who used these for his beautiful works. Messrs. Wedgwood, George Jones, and a few other makers of less importance, are reproducing it more or less successfully. To Messrs. Minton, however, we owe the revival of the ware, which, in connection with their majolica, created such a sensation in the French International Exhibition of 1855; and credit must be given to those gentlemen, for being on that occasion the promoters of that demand for artistic pottery, which has so largely developed of late. It is to satisfy this craving for novelties, that they have undertaken the imitation of the faïence d'Oiron, better known by the name of Henri Deux ware, a rare and costly one, which can only be produced in small quantities; and also their most recent improvement, the reproduction of the Persian wares.

In the old Persian pottery we find a real earthenware taking a precedence of several centuries over our own. There is little doubt that it can be connected with the early Arabian, Assyrian, and Egyptian, by the similitude of the processes common to all. I have no room to explain how it is that, being an earthenware, it is so much richer in colour than the modern ware made on this side of Europe. I can only mention that the body of the Persian ware may be converted into a transparent porcelain by firing it hard, which shows that the sandy clays from which these are made are sufficiently saline to become vitreous. To this they owe the property of receiving, without crazing, glazes of the softest kind, and consequently of exhibiting those colours which can only stand at a low temperature, such as the Persian red, the turquoise, and that purple or violet which makes so valuable the specimens on which it is laid. If we had in England sandy clays like those which abound in Persia, the reproduction of Persian ware would have been an easy undertaking; but in trying to reconstitute it by synthesis, there were several obstacles. Within the last three years, however, Messrs. Minton have sold a great many specimens of the ware, some of them of very large size. They may be recognized by the depth of the turquoise, which is sometimes as rich as Sèvres pieces of the best period. Their only competitors for this class of pottery are the manufactories of Worcester and of Messrs. Maw and Co.

I cannot leave earthenware without mentioning the plain and encaustic tiles, articles of comparatively recent manufacture in England, but whose consumption is increasing so fast, that it may be expected in time to afford a most valuable compensation, should circumstances restrict the production of some other branch of the trade. There is no need to dwell on the advantages offered by the use of tiles. They are clean, invaluable in a sanitary point of view, free from further deterioration and expense for maintenance, and susceptible of a variety of treatment which makes them admirably fitted for decorative purposes. To the Eastern nations we owe the idea of using ornamental tiles, and it is likely that it is from the numerous buildings existing in Western Asia and the north of Africa, at the time of the Crusades, that our forefathers took the notion of introducing in Europe the encaustic tiles; their ceramic knowledge being too limited to undertake the making of painted or enamelled tiles, an essentially Saracenic and Moorish production, whose specimens nearest to us are those to be seen in the Alhambra, or in the Alcazar at Seville. An inspection of those made afterwards in Spain, in the time of Charles V., or in Italy for the Vatican, and some of the palaces in Genoa, would prove that they were made exactly in the same way. From the contrast between the opaque and transparent enamels, these tiles have a very forcible and harmonious effect, not to be met in others (the Persian excepted, though these, exclusively decorated on a cool scale of colours, cannot answer so well the requirements of modern architecture). The majolica and Delft tiles, chiefly the last, have been almost exclusively used during the seventeenth and eighteenth centuries, and it is only within the last forty years, that we began to make them in earthenware. With the revival of this manufacture, and of almost any other sort of tiles, the name of Herbert Minton is closely associated. It was during his time, and with the assistance of Mr. Michael Daintry Hollins, that this great undertaking was carried out with such success, that hardly a new church or public building is erected where these tiles are not introduced. The making of plain tiles is new and peculiar. They are made from dry clay reduced to dust, which, being submitted in metallic moulds to a pressure of several hundred pounds to the inch, becomes so compact, that further contraction is almost suppressed, and they can be handled without risk of breaking. Encaustic tiles are made from plastic clay, in which the different portions of the design are sunk below the surface, so as to form recesses, in which slips of different colours are poured according to a set pattern. When these become as hard as the body of the tiles, the surface is made smooth and level with a steel scraper, which removes all the superfluous material, till the colours are shown standing neatly side by side with the greatest precision. It is a pretty process and interesting to witness. Besides the flooring tiles, there are many other sorts made for lining walls and fireplaces, varying considerably in style and material. There are two very extensive and perfected tile works at Stoke, viz. those belonging to Mr. Hollins and the Campbell Brick and Tile Company, in both of which all sorts of flooring and wall tiles are made. In the second, recently built, Mr. Colin Minton Campbell, the proprietor, has introduced new arrangements and contrivances in almost every department; all operations being performed on the ground floor, and in such manner that the goods shall travel the shortest possible distance from the moment they are begun to that of their completion. He has been the first to use Maw's patent steam presses for plain tiles, each of which can make twelve thousand tiles weekly, requiring only the assistance of a single person, to remove the tiles as they come out from the mould. It is by the intelligent use of these mechanical processes, that we may expect a reduction in the price of such a useful article. The firm of Mintons still continue to make their plain white printed and artistic tiles, along with their patent process for painting on mosaics. The Broseley Works, in Shropshire, belonging to Messrs. Maw and Co., have also a great name, and carry on an extensive business in tile making. Next are those of Messrs. Edge and Malkin, of Burslem. Messrs. Simpson, of London, are well known for their wall decorations in tiles painted by hand, and Messrs. Copeland, of Stoke, for their painted slabs.

The various porcelain biscuits known under the name of Parian or statuary biscuits, are specially used for statuettes, busts, and other articles for which it is desirable to get the appearance of white marble. This is a kind of hard porcelain made from a mixture of kaolin and felspar, in which the degree of hardness or fusibility is regulated by the proportion of one material towards the other. Of course, similar biscuits may be made by more complicated receipts, but the principle is always the same, viz. the taking advantage of the fusibility of felspar or Cornish stone, to secure the required amount of transparency. The light being allowed to penetrate to some depth below the surface, imparts to these biscuits a softness which is wanting in the similar productions of Sèvres, Germany, and Denmark.

In noticing the bluish-white colour of the foreign article as compared with the cream tint of our own, I must explain that this difference lies in the management of the fire, since in none of them is stain or colour introduced to procure any such result. As my readers must now understand, there is in all clays, pure as they may be, a certain amount of oxide of iron, which, during the firing process, forms silicate of protoxide or peroxide, according to the chemical composition of the atmosphere of the oven in which they stand. On the Continent, to make hard porcelain successfully, the fire must be reductive; while here, on the contrary, it is oxidizing; and it is to the formation of a small quantity of silicate of peroxide of iron disseminated in the mass, that the creamy colour of our Parian is due. Since this new material was introduced by Messrs. Copeland and Messrs. Minton, about twenty-eight years ago, a large quantity of figures, busts, and groups have been sold, and the talent of our most eminent sculptors has been put to contribution to get models adapted for this kind of ware. Parian is generally cast, which accounts for the great contraction it undergoes when fired, and much care is required for propping or supporting the various articles, as neglect or miscalculation in this respect would inevitably ruin them. Otherwise, as this biscuit is made from few materials and takes but one single firing, the simplicity of the manufacture has induced many small makers to undertake it—a fact that we should regret, if we were to take a purely artistic view of this subject. Parian, which was originally sold in biscuit state, has since been glazed, for the purpose of making pieces of decoration. The manufactory at Worcester, several years ago, made a great many coloured and gilt ornaments in the Cinque-cento style, to which it has lately added a highly artistic imitation of the Japanese lacquered ivories, for which great credit is due to the present director, Mr. Binns.

The Belleek manufactory, in Ireland, has obtained a name for coating its glazed Parian with an iridescent lustre, in imitation of a similar article invented by a Frenchman, M. Bianchon.

For richly decorated ornaments, the body of the Parian has been stained with success in many rich colours by Messrs. Minton, their last production in this class being a Parian combining the red colour of the terra cotta, with the advantages of a vitrified porcelain. Their most artistic ware is, however, their *pâte sur pâte*, in the production of which they have been assisted by M. Solon, an eminent artist, who left the Sèvres works to establish this branch of fine art in their manufactory. To carry on this process, advantage is taken of the transparency of the Parian body with which the figures or ornaments introduced in the composition are painted, or rather modelled. As they are laid on a ground of a dark colour, the softness of the shades in the thinner parts gives to the finished pieces a particularly beautiful cameo appearance. The effect may be compared to that of the Limoges enamels, when confined to the white colour. This process has a certain connection with that of Wedgwood for making his jasper ware; but there is this difference, that in the jasper, the figures and ornaments are taken from clay moulds, and may be repeated to any extent, the talent of the artisan consisting in pressing neatly and transferring on the vases the various fragments of decoration, without destroying the sharpness of the impression, while in the *pâte sur pâte* original works can only be produced by the artist, who must combine the qualifications of designer and modeller. What I say here is not in disparagement of jasper, which, considering the time of its introduction, was far in advance of anything that could be expected. In its production the Wedgwoods never had a rival, and the models of the celebrated Josiah Wedgwood are still worked at their manufactory at Etruria, with the same success. The sulphate and carbonate of barytes were the fluxes originally used to vitrify the body of the jasper ware, and on this account it ought to be classified with the stoneware. Parian, which may be made from purely granitic materials, has a nearer connection with porcelain.

There are three different sorts of porcelain: 1. The Chinese and Japanese, with which may be assimilated the German and French, all of them made of kaolin and felspar, sometimes with an addition of quartz. The principal seat of this manufacture is now in France, with Limoges for its centre. 2. The soft porcelain, of which the most perfect type is the old Sèvres, includes those of Chelsea, Bow, Worcester, and Derby. In all these the transparency, which is the distinctive feature of porcelain, is secured by the introduction of *fritt*, a mixture of sand and alkaline materials thoroughly vitrified, ground and made workable by an addition of plastic clay. The calcareous marl used at Sèvres gave to the French works a superiority over the English, who could only use the clays from our southern counties. The manufacture of the soft porcelain, on account of its difficulties, is almost abandoned. 3. The English porcelain, the body of which is made, like the hard, from kaolin and Cornish stone, but differing from it by the addition of a large proportion of calcined bones. This kind is exclusively English. For the hard porcelain, the glaze is made from felspar containing a variable quantity of quartz, or, as in Germany, from quartz vitrified by an addition of gypsum, the melting of which in both cases requires a very high temperature. For the glazing of the two other classes of porcelain, a soft, vitreous mixture containing silicate of lead and borates is used, the temperature necessary to melt these being much inferior to that required for firing the biscuit.

The most ancient porcelain is, as everyone knows, the Chinese, which, relying on the few authorities that have written on this subject, may have been in existence for two thousand years, and is said to have reached its greatest perfection towards the eleventh century of our era. The Portuguese have the credit of having been the first to introduce it in Europe, in 1520; but it is not improbable that, before they doubled the Cape of Good Hope, some specimens were brought to Europe through India and Persia. This may be inferred from the mention by ancient historians of some extraordinary white vessels, which could hardly correspond to any other kind of ware. The Portuguese and the Dutch, who were the first to explore the Chinese seas, seem to have derived a good trade from the importation of the porcelain into Europe, and, since then, the reproduction of that refined pottery was the ambition of many alchemists, who pursued their experiments in that direction with an eagerness almost equal to that wasted in the search for the philosopher's stone. For a long time, in consequence of the imperfection of their chemical knowledge, their efforts ended in failure. The only successful attempt was that of Francis II., one of the Medicis, who produced a few pieces of soft porcelain recognizable by their mark, representing the dome of Florence.

At the death of this prince, his secret was lost, and it was a long time afterwards, at the end of the seventeenth century, that John Dwight, a potter, of Fulham, in Middlesex, took a patent for what is curiously reported by Dr. Plot as "*the mystery of transparent earthenware commonly knowne by the name of porcelaine and Persian ware*." Made from English materials, it is probable that this was nothing better than a kind of white stoneware, possessing little of those qualities which would entitle it to the name of porcelain. Next to that in date would be the soft porcelain made at the manufactory of St. Cloud, which was said to produce, in 1698, pieces of ware considered very good imitations of the Oriental. This was the origin of the French soft porcelain, which was carried on afterwards with varied success at Chantilly, Vincennes, and other places, till it was definitely settled, in 1756, by King Louis XV. in the royal establishment of Sèvres. At a corresponding period, on this side of the Channel, the efforts of our potters were varied and numerous. If we are to believe Dr. Martyn Lister, a manufactory of porcelain existed at Chelsea as far back as 1698, a fact which would establish for England a claim equal to that of France for the discovery of the soft porcelain. This is not altogether improbable, considering that there was a glass manufactory in that locality before that, and that many people had a notion that porcelain was nothing else than a glass hardened and made opaque. The managers of these glass-works may have experimented on that supposition, and the conjecture is strengthened by the fact, that pounded glass was always used at Chelsea to give the desired transparency. Good specimens are not, however, recorded before 1745, and it is probable that many of the improvements at Chelsea were realized by the Staffordshire potters, who, two years later, went there to apply their industry. The priority in making practically good ware belongs to the works established in 1730 at Stratford-le-Bow, from which the Bow porcelain took its name. It was not perfected there, however, before 1744, when a china, softer than that made at Chelsea, and nearer to that made at Vincennes, was manufactured by a potter named Frye, originally a painter, who seems to have been the promoter and manager of these works, which at one time did not employ less than three hundred people.

Bow was celebrated for its statuettes, and it is said that several of them were modelled by Bacon, the sculptor. The successes of Bow and Chelsea were great but of short duration, for both had ceased to exist in 1775, when their utensils and moulds were sold to Mr. William Dwesbury, and carried to Derby, where this enterprising gentleman had started a manufactory as far back as 1751.

Three generations of Dwesbury continued here the traditions of Chelsea, after which time the works became the property of Robert Bloor, the last owner of repute. I am happy to say that after ceasing to exist for a great many years, this celebrated manufactory is going to be revived under the leadership of Mr. E. Phillips, formerly one of the directors of the Worcester works. In that same year (1761), a man—who for his inquiring turn of mind and artistic knowledge seems to have a great likeness to Josiah Wedgwood—Johu Wall, a doctor and a chemist, began also to make porcelain at Worcester; and if Mr. Binns' assertions are correct as regards the preparation of the fritt used in it, he must have had some knowledge of the Vincennes receipts. The Worcester works have now been celebrated for more than a century, and with them must be associated the names of the various owners, Flight, Barr, and Chamberlain. At Caughley, in Shropshire, a manufactory of soft porcelain was in existence in 1756, and it was employed at one time by the proprietors of the Worcester works to assist in making ware, which was sent back to them to be decorated. The Caughley works were bought by John Rose, a pupil of Turner, the first director, and transferred to Coalport, with which the works of Nantgarw, in South Wales, were also amalgamated. These works have been in the family of John Rose until lately, when they came into the possession of M. Pew, the present owner. For softness and resistance of body, brightness of glaze, and clearness of colour, the Coalport ware is held in great esteem by those who know anything about china. At Swinton, in Yorkshire, soft porcelain was manufactured on the property of the Marquis of Rockingham. Manufactories also existed at other places, so that the reader may here remark, that all exertions to establish the manufacture of china were made outside Staffordshire; and if he has noticed the dates, he will also perceive that all these works were founded, when Wedgwood was too young to render any assistance. This we must say in justice to Dr. Wall, Frye, Dwesbury, and Cookworthy—whose name must not be forgotten as the discoverer of the Cornish clay, which so greatly promoted the ceramic trade of this country. William Cookworthy was a chemist and druggist, at Plymouth, a member of the Society of Friends, and a man of great respectability. Having had the opportunity of seeing some kaolin and felspar from Virginia, that an American friend had shown to him as the very material from which the Chinese porcelain was made, he recognized, several years afterwards, the same in Cornwall, and setting resolutely to work, he began to make his first trials at St. Stephens, on the property of Lord Camelford, and afterwards at Plymouth, where he remained till 1774, when Champion, a merchant of Bristol, bought his patent, and removed the works to the latter place. I must here explain that Cookworthy's ideas of the making of porcelain were correct, inasmuch as he wished to closely imitate the Chinese; consequently he had to work on different principles from those then in favour at Chelsea and other places. He wanted to produce a porcelain without fritt and with a felspathic glaze, and, in succeeding in his attempt, this energetic man is entitled to a great deal of credit, when we consider that, although the processes discovered by Bottger, in 1710, at Meyssen, for making hard porcelain, were also put in practice at Vienna, St. Petersburg, and Berlin, they were kept very secret, and it is most probable that he had no information whatever from those quarters. It would be to rob Cookworthy to admit that the hard porcelain pieces, known by the name of Lowestoft, were made in that locality. I am indeed sorry to differ in this from an eminent critic, who has taken great trouble to collect documents in support of this opinion; but those who are in favour of it know very little about the difficulties attending the organization of such manufacture, and the quality of the materials that it requires. Besides the absence of any information respecting the place whence these materials were taken, the vast quantity of pieces which are met with is such, that it precludes the idea that they have been made in the precincts of such a small establishment. They have every feature of Chinese porcelain, and of one made in large quantities. It is most probable that, after making, or trying to make, soft porcelain for a time, the proprietors of the Lowestoft works found it more profitable to paint and decorate the foreign article, which they could easily get from Holland in the white state.

Most pieces of Cookworthy manufacture were copied from the Chinese, and are still well known by the name of Plymouth porcelain. At Bristol, Champion used the same clay to produce a softer kind of ware, and his materials began to be employed at Bow and other places. The Staffordshire potters soon became anxious to take advantage of the discovery, and in 1777 a company was formed by Jacob Warburton to obtain a licence for their use. This was granted by Champion, but with this singular restriction—that, although they were allowed to use a certain quantity of china clay and china stone, they were not to make porcelain. This restriction, however, did not last long, and Champion himself came for a short time to Shelton to superintend some works. Amongst the names of Warburton's associates, we notice some well known in Staffordshire, such as S. Hollins, of Shelton; Antony Keeling, of Tunstall; Turner, of Lane End, and a few others. To these gentlemen we must give credit for the earliest attempts to introduce the manufacture of china into the Potteries. However, their porcelain was inferior to that made at Worcester and Derby, and it is doubtful whether they would have persisted, if the matter had not been settled by Josiah Spode, the second of that name, who, by adding calcined bones to the body of the ware, made a new kind of porcelain, distinct from the hard or the soft previously made. On that account Spode deserves to be considered as the creator of the English porcelain. There is this peculiarity in the use of bones, that the phosphate of lime which enters into their composition is not decomposed by the silicates with which it is mixed, and, as it is infusible, its admixture in the body allows the ware to stand without injury the temperature at which the felspar is vitrified. This hardening of the bones does not exclude a certain amount of transparency, and they possess, besides, a very great advantage in preventing the oxides of iron which exist in the clays, producing that brownish or imperfect transparency, noticeable in the old Derby or Worcester ware. I have already said that the adaptation of the glaze for each kind of pottery is one of the greatest difficulties that the maker has to overcome; in this case, however, there was very little, and the glazing of English porcelain may be considered as exceptionally easy. Most of the glazes which had been used for the soft porcelain could be adapted to this one, a property which was of great service when the pieces had to be decorated. I have already explained, that when paintings executed on the surface of the ware are submitted to a moderate red heat, if the glaze is soft enough to undergo an incipient fusion, the vitreous colours with which they are executed will sink into it and attain, by their incorporation, an amount of glossiness and brilliancy which cannot be got on the surface of hard glazes. This is particularly illustrated by the old Sèvres ware, which possesses this quality in the highest degree. English porcelain, well-made, has almost all the advantages of the old soft, and its making is not attended with the difficulties experienced in working a body made from fritted substances. For regular use, it is not much inferior to the hard porcelain. When this last began to be made on the Continent, people were so much prejudiced in its favour, on account of the capability of its glaze to resist the scratching of the knife, that this was thought to more than compensate for its inability to combine with the colours. The advantage was, in fact, more apparent than real, for when hard porcelain has been long in use, it becomes as badly scratched as the English. Some people question whether it would not be desirable to revive in England the manufacture of the hard. There are many reasons against this, the principal being, that in case we succeeded, we should have to compete with the French and Germans, who get their labour cheaper, and have a long experience of processes altogether different from ours; and by the change we should lose the advantage of our traditions, and depend, at least for a time, on foreign labour to give a new training to our workmen. Out of the trade, few people seem to know that the price of hard porcelain is generally lower than that given for the English; and, if the experiment were made, it would be soon found that with greater risks we should produce an article of less value, and consequently less remunerative. It is true that the exports of our best china are very small, on account of its price; but with the improvement going on in the public taste, it is likely to increase, and there are signs that eventually our richest articles may find purchasers on the other side of the Atlantic.

In Europe, where the value of the various ceramic productions has been more investigated than in the other parts of the world, there is hardly an amateur who does not recognize the superiority of a soft porcelain for decorated articles, and if the English china is not, properly speaking, as soft as the old Sèvres, it is certainly nearer to it than any other porcelain. This superiority is proved by the test that the various porcelains are undergoing at the present time, and which is rather decisive. We understand by this, the manner in which they have stood the dangerous competition arising from the introduction of artistic faiences or painted majolica. While, in consequence of this, the French manufacturers have seen the production of ornamental articles in hard porcelain collapse to an incredible extent, the quantity of those made in England for similar purposes is fast increasing.

Messrs. Copeland, whose father, the late alderman, was for some time in partnership with Spode, occupy, in Stoke-upon-Trent, the same establishment in which that great potter carried out his improvements. Since then, these makers have kept their rank among the principal leaders of the trade, and maintain their reputation for the excellence of their decoration and the beauty of their gilding. It was so far fortunate for Stoke that, although one of the smallest towns in the Potteries, it became the seat of the most important manufactories of china. It was in 1788 that Thomas Minton, who had been brought up as an engraver at the Caughley works, in Shropshire, and who in that capacity had been several years in the employment of Spode, founded in that town the establishment which subsequently became the property of his son, Herbert Minton. The father does not seem to have possessed these qualities which, as potter, should entitle him to a special notice; but the same cannot be said of the son, who soon after his father's death began to work in earnest to raise his manufactory to its present degree of eminence. The unceasing activity of his mind in carrying out improvements in all the branches of his trade, may be attested by one who for many years had the honour of working with him. On every matter connected with art his ideas were sound, and his natural tact rarely failed in finding out that which was most suited to the taste of his customers. His reputation, as the most advanced potter of his time, is so well established, that I am not astonished to find others claiming a share in it, asserting that it was at their suggestion, or with their assistance, that he left the old path to open the way to progress. Suggestions and advices are always freely given to a man of sociable disposition as was Herbert Minton, but he used his own judgment and discretion to test their practicability. In applying higher class of art to his productions, he had only to follow his own inclinations, guided by that care and prudence which are inseparable from good administration. He knew how to select his assistants, and was particularly fortunate in his partners, his two nephews: Michael Hollins, who, since he left the firm of Minton, is the owner of a large tile manufactory at Stoke; and Colin Minton Campbell, his pupil and heir, who, after taking an active part in all his labours, has so successfully followed the example set by his uncle, that Minton's manufactory is now the largest in existence, and turns out the greatest variety of ware. With Minton and Copeland must be associated the names of Messrs. Brown-Westhead, of Caulden Place; and outside Staffordshire, the Coalport works and the Royal manufactory at Worcester. These are the principal producers of richly decorated china, for which the demand has greatly increased during the last few years. The greatest bulk of that ware is, however, made at Longton, one of the pottery towns which has a reputation for the cheapness of its goods; but of late a decided tendency to improve their quality and prices must be noticed among the generality of its manufacturers. Several of them, like Messrs. Ainsley, Moore, Barlow, and others, are trying to raise their goods to the same level as those of Stoke. There are about thirty-five firms in the Potteries making china, most of them for the home trade, and over five times that number making earthenware. These two hundred and thirty manufactories are spread over an area of ten square miles, comprising the towns of Hanley, Burslem, Tunstall, Longton, Fenton, Shelton, and Stoke-upon-Trent, from which the electoral borough takes its name. These, which in a few years are likely to be amalgamated in a single town, form the district called the Potteries, containing already a population of 170,000 inhabitants engaged in the ceramic and iron trade. It has been remarked that since the foundation of Burslem, the mother town of the Potteries, the population of the district has doubled every twenty-five years, and it is easy to foresee the time when Stoke-upon-Trent will rank in importance with our largest commercial cities.

The export of porcelain is not large; but that of earthenware reaches one and a half million of pounds. This does not appear large compared with the enormous amount exported by the iron or the cotton trades, but it is satisfactory, if taken in combination with the quantity absorbed by the home trade, which represents quite as much. Our colonial trade with Australia, India, and British America is decidedly on the increase, and the same may be said as regards South America. On the contrary, our transactions with the Continent of Europe have a tendency to decrease, and to fluctuate in the case of the United States, a very important market, which, in time of prosperity, would take as much as 800,000*l.* of granite ware.

To meet the competition of France and Germany, on one side, and the Americans on the other, great changes have taken place in the management of our works. Several processes have been improved or simplified, and large manufactories have been built on better principles. These steps were not taken too soon; for if competition scarcely existed for our goods twenty years ago, that state of things has been much altered, and it will require a great deal of application and energy on our part, if we intend to maintain our position as the largest and best producers of pottery in the world.

It is a fact that America, which had not a single manufactory worth the name at the time of the New York Exhibition, produces now, with the assistance of British workmen, granite ware of tolerably good quality; and I have been told by an eye-witness, that no less than seventy ovens are now at work at Trenton, in New Jersey. The clays and coals used by these potters are good, and if the salaries are higher than they are in England, they find a compensation in the heavy duties which, since the war of Secession, are levied on our wares.

Our commercial intercourse with France has not much altered, and the quantity of our goods sent across the Channel may be considered small compared with the importance of this market. The French are the largest producers of hard porcelain, and they make their common earthenware quite as cheap, if not cheaper, than ours. However, if they are strong at home, they have never affected our trade abroad, except in the United States, where they send their porcelain in competition with English granite.

At the present time, the rivalry from which we have suffered most in Germany, the North of Europe, and as far as Italy, comes from a group of establishments situated in the Rhenish provinces and that neighbourhood: at Sarreguemines, Sarrelouis, Vaudrevange, Mettlach, Maestricht, and a few other places. Built in the centre of a populous district, where labour is still very cheap, their intelligent and wealthy proprietors share in each other's business, and consequently have no inducement for lowering their prices. They seem to have given a considerable portion of their time to the study of the various processes, and they have so far succeeded, that they are a great deal more independent with regard to their men than we are. Possessing these advantages, we cannot wonder, if we have not been able to keep our hold on those markets which were the nearest to them. Besides, it is plain, that the important rise which has taken place in the price of wages and fuel, and the consequent increase in the price of our wares, has acted as an encouragement to foreign production; and perhaps it may be good policy, in future, to resist any further opportunity which might offer to increase the price of our goods. It would, however, be singular if, in the course of time, England did not derive some benefit from this competition; she is used to close contest, and, everything considered, her position is an enviable one. Our home trade is excellent; and if the amount of our exports does not progress so fast as we could desire, we know that we have in our commercial fleet more facilities that any other nation for sending our goods to those numerous countries where the trade of pottery is hardly established, and we rely on our honest and straightforward way of dealing, for securing new customers for English manufacture.

GLASS AND SILICATES.

By Professor Fredk. S. Barff, M.A.

The very brilliant and useful substance, which forms the subject of this article, is said to have been discovered by the Phœnicians. The story goes that some Phœnician merchants, while cooking their food on the sands near the seashore, noticed that the ashes of the plant, with which they made their fire, caused some of the sand to melt and form a vitreous substance; but whether this tale be true or not, it is well known that for a long time these people made glass from the materials which were abundant on their sea and river coasts.

Glass, however, was produced long before this by the Egyptians for the beads and ornaments used in adorning their mummies, and many specimens of these are in the British Museum. It is certain also that they well knew how to make certain substances impart colour to glass for the manufacture of most of these beads. The Romans made rich goblets of ruby glass, some of which are to be seen in collections in this country, as well as urns to receive the ashes of their dead, four of which, of a green colour, are also in the British Museum. The manufacture of these vessels proves that this nation was well skilled in the arts of blowing and modelling glass; and their designs, which we are now reproducing, show that they were at least not inferior in artistic skill to those who have formed their taste in this highly civilized age. We have no record of glass being used for glazing purposes in ancient times. The Venerable Bede introduced it into this country about 674 A.D., and employed it in the adornment of church windows. Ordinary window glass was made at the works in Crutched Friars in 1557, and plate glass at the large works of the Ravenhead Plate Glass Company, near St. Helen's in Lancashire. About 1776, flint glass vessels were blown at the establishment in the Savoy House; and the second Duke of Buckingham brought over Venetian artists, at that time the most skilled, to make glass for mirrors, carriage windows, and other useful purposes. Their workshop was in Lambeth, and the date of their arrival in this country was 1673. The French were before us in the art of casting glass plates; and in 1688, Stewart commenced this branch of manufacture, which led to the establishment of the very famous works of St. Gobain. England has now large plate glass factories in different parts of the country, and these together yield as their weekly production at least 140,000 superficial feet of the best polished plate, or seven and a quarter millions of feet yearly. The value of plate glass made in England annually, including the rough kinds used for glazing roofs, &c., is estimated at 1,000,000*l.* France still stands very high, and her plates are extremely perfect in manufacture. St. Marie d'Oignies, in Belgium, also sends a considerable quantity of plate glass into the market. This branch of manufacture has not yet extended to America, which therefore is a large customer of Europe. Formerly, glass making was very heavily taxed in this country, and in 1812 an additional duty was placed on the manufacture of the raw material, which so greatly depressed it, that the income which the State received fell from 328,000*l.* to 183,000*l.* per annum. Moreover, large quantities of foreign glass were imported, and this too hindered the development of the industry amongst us. On the repeal of the duty, however, the trade began to increase, and has now reached very large dimensions.

Glass appears to be a mixture of silicates, the nature and chemical composition of which will be explained in a later part of this article.

The materials used are principally sand, with an alkaline substance, either a salt of soda or potash and lime, though in some kinds of glass, oxide of lead takes the place of lime. Other materials are generally employed to correct impurities which may occur in the sand, and which, if present, always impart an objectionable colour to the glass.

There are two kinds of glass in ordinary use: common window glass, which may be divided into sheet, crown, and plate; and flint glass, which is used for decanters, wine-glasses, and tumblers; and, in some special forms, for ornamental stones in imitation of jewels, and also for lenses of telescopes and microscopes. The materials for making these different kinds vary somewhat, although the principal constituents are the same, viz. sand with some salt of soda or potash.

The scientific name for sand, or more properly for its principal constituent, is silica. This compound silica, or oxide of silicon, also called silicic acid, possesses properties similar to those which belong to other acids, namely, it is able, when brought into contact with bodies of an opposite character under suitable conditions, to unite with them and to form salts. Everybody knows, that if tartaric acid be added to carbonate of soda, an effervescence takes place; carbonic acid passes off in the gaseous state, and the residue is composed of a portion of the tartaric acid, which unites with the soda, a double decomposition taking place. If silicic acid be mixed with carbonate of soda, and if the mixture be heated to a high temperature, that is, to a white heat, for some length of time, the same kind of action occurs: carbonic acid goes off, the silica or silicic acid uniting with the soda; and inasmuch as the soda salt was originally called *carbonate* of soda, after this action, in which carbonic acid is replaced by silicic acid, it is called *silicate* of soda. Silicic acid at the ordinary temperature of the air and in the dry state, has no action whatever upon carbonate of soda, but when heated sufficiently, the action becomes vigorous. A very interesting experiment may be performed in illustration of this fact in the following manner: if a mixture of carbonate of soda and carbonate of potash be heated in an ordinary fire-clay crucible, and if, when the mixture is melted, some perfectly dry sand be poured into it, effervescence will take place, owing to the expulsion of carbonic acid from the carbonate of soda and potash by means of the silicic acid. If the operation be performed in such a vessel that the carbonic acid can be collected, its presence is readily indicated by the usual tests. This experiment can be easily made by anyone who has ordinary chemical apparatus at his command. If the mixture of carbonate of potash and carbonate of soda be melted in a small platinum crucible; and if, when melted, it be removed quickly while very hot into a tall beaker-glass, and sand be then poured into it, the escaping carbonic acid will, on account of its being heavier than air, be retained in the glass, and its presence can be recognized by its turning lime-water milky (which is, in fact, a solution of lime in water), owing to the formation of carbonate of lime produced by the carbonic acid evolved uniting with the lime dissolved in the water. A mixture of carbonate of soda and carbonate of potash is here used, because either of these salts requires a very high temperature to melt it; but when the two are heated together, the fusibility of both is increased. When sand is heated with oxide of lead (common litharge) they unite, forming a compound similar to that produced by the silica uniting with the soda, as described in the last paragraph. In the first case, a *soda* glass is formed; in the second, a *lead* glass is the result. If these two glasses be mixed together and melted in a crucible, and if the proportions in which they are mixed be properly adjusted, and the materials used be pure, a colourless and transparent glass will be formed, similar in appearance to that which is employed in the manufacture of decanters and tumblers. The same kind of glass may be produced by mixing all the materials in due proportions and heating them together. If, instead of oxide of lead, lime be mixed with carbonate of soda and sand, and the mixture be heated to a high temperature, a glass will be formed, in many respects similar to that of which oxide of lead is a constituent, but differing from it in several important particulars. First of all, the lead glass is highly lustrous, and has a great power of refracting light, so that, when it is cut, it presents a brilliant appearance, and by refraction readily produces the prismatic colours. This property does not belong to the glass containing lime, to anything like the same extent. Lead glass, too, is much heavier than lime glass, and is therefore unsuited to many of the purposes for which the latter is generally used, the principal of which is for the glazing of windows.

If, instead of oxide of lead, which is a chemical compound of lead and oxygen gas, or lime, which likewise is one of the metal calcium with oxygen, *carbonate* of lead or of lime be used, the silicic acid will expel the carbonic acid from these substances at a high temperature, just as it does the carbonic acid from the carbonate of soda and carbonate of potash. It is necessary, for a proper understanding of the scientific part of our subject, that this fact should be borne in mind, and that the acid properties of silica should be thoroughly recognized. Formerly, carbonate of soda was used in the manufacture of ordinary window glass, but now it is found more economical to employ *sulphate* of soda, which is a much earlier product in the manufacture of soda from common salt than the carbonate, and is therefore less expensive. Carbonic acid is what chemists call a *weak* acid, by which is meant, that its compounds are not so firm and stable, as those which are formed by other acids with the same substances. Sulphuric acid is a strong and powerful acid, uniting very readily with the oxides of certain metals to form very stable compounds. But although this acid is chemically so powerful in its compounds, yet at a high temperature it is expelled by silicic acid, showing that this substance, so inert in its natural state and at the ordinary temperature of the air, becomes exceedingly active in expelling other acids and in forming compounds, when put under favourable conditions.

If a mixture of common sand and carbonate of soda, the carbonate of soda being in excess, be heated, a glass will be obtained which is slowly soluble in cold, readily soluble in hot water. To these compounds the name of silicate is given, so that we speak of the soda compound as silicate of soda, of the lead compound as silicate of lead, and the lime compound as silicate of lime. Silicate of soda and silicate of potash, when the alkali, that is to say, the soda or potash, is in excess, are both soluble. If a solution of one of these silicates be taken, and if carbonic acid be passed slowly through it, after a time a gelatinous, white, flocculent substance will be formed in the liquid, and eventually precipitated. This white flocculent substance is silicic acid combined with the elements of water, and is therefore called by chemists hydrate of silica. Now this hydrate of silica is soluble in water and in hydrochloric acid; and the method by which it can be brought into solution in water will be explained, when treating fully of what are called soluble silicates and their applications.

Soluble silicates are mentioned here, in order that a more perfect understanding of the nature of silicious compounds may be obtained, by those who do not possess a scientific knowledge of chemistry. The silicic acid in the silicate of soda is precipitated or separated out by carbonic acid, and hence it appears, that an action, exactly the reverse of that which takes place at a high temperature, occurs, when the silicic acid is removed from those conditions in which it has been seen to be (chemically) so active.

Suppose that to a solution of silicate of soda or of potash a soluble salt of calcium be added—the chloride, for example, which is a compound of the metal calcium with chlorine—a double decomposition will take place; the calcium will unite with oxygen in the silicate of soda, forming lime; and this will again unite with the silicic acid, forming silicate of lime; while the chlorine will unite with the sodium, forming chloride of sodium, or common salt.

Here then, silicate of lime is obtained by a process very different from that which has already been described, namely, by the heating of lime with silica at a high temperature. The body formed in the latter case is chemically the same as that produced in the former, there being present the same weight of calcium, the same weight of oxygen, and the same weight of silicic acid in each. Again, if to a solution of silicate of soda, one containing a soluble lead salt, such as the nitrate, be added, the silicic acid will unite with the oxide of lead in the nitrate of lead, and the acid constituent of that body will unite with the oxide of sodium or soda, forming nitrate of soda. It is apparent, therefore, from these remarks, that in whatever way the substances be made to unite, the effects produced as regards chemical composition are the same. If some of the silicate of lime or silicate of lead made by precipitation be dried and heated to a high temperature in a crucible, it will melt or fuse, and form a vitreous substance. In these last cases, as in many others which will have to be alluded to, the silicates formed are not soluble in water, although silicate of lime may be partially dissolved when heated in water under extreme pressure, by which the temperature is considerably increased, and even slightly in cold water.

To ensure the production of definite silicates by the agency of heat, the materials must be mixed together in proper combining proportions; for if more of the metallic oxide is introduced than can combine chemically with the sand, it will be melted in the mass, but the excess will not form a definite compound; whereas by precipitation, the silicates formed always have, when thoroughly washed, a definite composition. This subject will be again referred to, when the manufacture of commercial glass is described.

It has been noticed that the glass found in the windows of old churches and in other places where it has been exposed to the prolonged action of the air and of moisture, has gradually become rough on its surface, and has lost to a considerable extent its transparency. This, which would be a defect in glass for the glazing of ordinary windows, where transparency is desired, is rightly regarded as a beauty in glass which is to be used for the ornamentation of windows. Many reasons have been offered in explanation of this apparently peculiar property of ancient glass; and that which appears to be correct is, that glass is a mechanical mixture of different silicates, some of which may be soluble in water, and others insoluble. The old window glass, whose manufacture will be more fully described by-and-by, was made in a less perfect manner than modern appliances enable glass manufacturers now to produce the same article, so that the silicates composing the old glass were not as intimately mixed as those used in modern glass. By the slow action of air and moisture, portions of the soluble silicates have been dissolved out, and hence we frequently find a sort of honeycomb appearance on the surface of ancient glass, as well as a thin film, which, by refraction of light, causes an opalescence when viewed by reflected light. Efforts have of late been made to produce a similar effect by employing different methods in the process of manufacture, but without complete success. The fact, however, that such changes have taken place in this less perfectly fused glass, tends to show, that if one silicate can be dissolved out, there cannot be *chemical* union between all the silicates. If a piece of modern window glass be heated in water under pressure in a closed vessel, it will present somewhat the appearance of ancient glass, for a considerable quantity of soluble silicate will be dissolved out from it. The object in dwelling on this matter here, is to induce makers to attend more to the chemical composition of their glass, for, doubtless, much more satisfactory results would be obtained both as to the quality of the material and the cost of its production, if thoroughly scientific investigations were conducted by a competent chemist.

MANUFACTURE OF GLASS.

The first object in glass making is to obtain suitable materials. The sand which is employed for window glass differs from that which is required for flint glass, in that the latter should be as pure as possible. The maker can correct the impurities in the window glass sand, provided they be not present in too great quantities; but it is far more difficult, in the case of flint glass, to chemically counteract the influence of those substances which might impair its tint. So that the manufacturer would rather pay large prices for his sand, than trust to expedients which in their application might fail, and thus cause a greater loss.

One of the principal and most troublesome impurities met with in sand, is iron in the form of oxide. There are two oxides of iron: one, the protoxide, which imparts a green colour to glass; and the other the peroxide, whose staining property is yellow. A very small quantity of the former will give an appreciably green tint, whereas it requires a large quantity of the peroxide to produce even a delicate yellow. In all glass making, it is found necessary to use something which will counteract the colouring properties of these two oxides. The material employed was black oxide of manganese. This is still used in certain glass-works, but from its injurious action on the fire-clay pots, arsenious acid or common white arsenic is employed to effect the same object. The chemical action in the two cases is different: the black oxide of manganese is what is termed an oxidizing agent, and gives up, at a high temperature, a portion of its oxygen to the protoxide of iron, thereby converting it into the peroxide. It thus becomes comparatively harmless, by converting a quantity of that oxide, which gives a green colour, into the other oxide, which has little or no power of colouring, except it be present in large quantities. The difficulty in using black oxide of manganese is, the exact proportioning of it to the quantity of iron present in the sand, a quantity which cannot be easily determined. If the black oxide of manganese be used in excess, some of the oxide of manganese remains unreduced, and, when this is the case, it gives a purple colour to glass. If used in exact proportions, it is reduced to an oxide which does not impart colour to glass. This may be seen in many of the old plate glass windows which were employed for glazing purposes some sixty or seventy years ago, the colour of the panes being generally purple.

Since this article was written, I have been consulted by a glass firm of eminence, as to the use of pure black oxide of manganese in the manufacture of flint glass, instead of that ordinarily supplied in commerce. The black oxide of manganese usually sold contains many other constituents besides black oxide of manganese; amongst these are iron, copper, cobalt, and alumina.

The iron, as will be seen from what has before been stated, is a decidedly objectionable ingredient to use along with the manganese.

Copper and cobalt both stain glass, the former of a bluish-green colour, while the latter makes it blue; and a small quantity of the latter has great staining power. I have thought it advisable to give analyses of the black oxides of manganese, and they are as follows:

Binoxide of manganese (Molecule, $Mn.O_2$), is found native as pyrolusite or polyanite. Appended are two analyses of pyrolusite containing sesquioxide of iron.

Red oxide of Manganese	87·0	72·5
Oxygen	11·6	9·8
Sesquioxide of Iron	1·3	4·2
Alumina	0·3	
Baryta	1·2	
Lime	0·3	
Silica	0·8	1·4
Water	5·8	1·6
	108·3	99·5

The native binoxide often contains both copper and cobalt in addition to iron; frequently to the amount of as much as 1 per cent. of copper and about ·54 per cent. of cobalt.

Wad, a native binoxide of manganese, sometimes contains 54·34 per cent. of iron, while nearly all the manganese ores contain more or less alumina, varying from ·5 per cent. to as much as 20 per cent.

From the composition of ordinary commercial black oxide of manganese, as shown by these analyses, it is evident that it is better to use the pure article, and this has been found to be the case by the firm who have adopted it in lieu of commercial black oxide of manganese. I therefore strongly recommend all glass makers to try and experiment with it, for the results obtained will largely counterbalance the extra cost of the pure material; and I also much doubt whether the same injurious effects will be produced on the pots, as is the case where commercial manganese is employed.

Arsenious acid also acts as an oxidizing agent, in that it gives up its oxygen to the protoxide of iron, converting it into the peroxide; but the arsenic itself, which has lost its oxygen, is reduced to the metallic state, and being volatile, does not remain with the glass, but passes off by the flues of the furnace. If too much arsenic is used, it sometimes renders the glass milky or cloudy.

Before describing in detail the method of mixing and founding glass, it will be necessary to mention the composition of the vessels in which the glass is made. They are called glass-pots, and differ in shape according to the different kinds of glass to be made in them. Glass-pots are made of fire-clay (generally the best Stourbridge), which is a silicate of alumina, and here great care is taken to select that which contains least lime or iron. It is ground, then moistened and well kneaded together, and left to ripen, while a certain quantity of old glass-pot is ground fine and mixed with the fresh fire-clay. Masses about the size of two hands are kneaded separately, the object being to exclude all air bubbles, and to obtain a perfectly homogeneous lump. The bottom of the glass-pot is then laid, the masses of fire-clay being pressed in with the greatest care, so as to avoid all cracks or places where air might enter during the slow process of drying.

The modern shape is round; though formerly certain glass-pots, called *cuvettes*, used in the purifying of plate glass, were square. Pots used in the manufacture of common crown and sheet window glass, generally speaking, are larger at the top than at the bottom; but whatever may be the shape of the pot, the method of its building is the same. The sides are carefully made of fire-clay, each piece being laid on by itself and kneaded like the bottom of the pot, so that it is slowly built up until it reaches the desired height. It is then dried very gradually, and the process is finished in artificially warmed chambers. Before putting it in its place in the glass-furnace, it is allowed to remain for some time in what is called a pot-arch, that is, an archway built of fire-clay bricks, along the side of which is a fireplace, by means of which the arch is brought up to a red heat; and after it has been heated sufficiently, is removed while red-hot and put into the furnace. Glass-pots are never allowed to cool, and with care they may last for several months. From this description of their manufacture, it will be clear that it is attended with considerable cost, varying from 5*l.* to 10*l.*

There are three different kinds of ordinary pots for crown, plate, and flint glass; and of these the last is decidedly the most expensive, as its top is covered over, and presents the appearance of a dome with an opening in front, through which the materials can be introduced when the pot is charged, and from which, when made, the glass may be drawn, in order to be blown into shape by the workman. In glass-furnaces the pots are sometimes arranged in a circle, with their mouths opening into the glass-house; but now a different construction is sometimes employed, since other methods of heating the furnaces have been introduced. It is hardly within the scope of this article to enter into a description of glass-furnaces; suffice it to state, that they should be of such a construction as to yield the greatest amount of well-regulated heat for the smallest consumption of fuel, and this object seems to be best effected by the adoption of Mr. Siemens' excellent principle of heating furnaces. For some years his process has been in use at the Thames Plate Glass Company's Works, where the saving of fuel has been very considerable, and the glass greatly improved, owing to the fact that impurities from the fuel employed cannot possibly find such easy entrance into the glass-pot. In any case, the construction of the furnace is such, as to be best adapted to the convenience of the workmen, according to the kinds of glass which they have to make. Differently arranged furnaces are used for bottles from those employed for crown and sheet glass.

It has lately come to my knowledge that flint glass, that is to say, the glass used for tumblers, decanters, and such like, is occasionally injured by the appearance in it of little opaque white spots. Some portions of glass of this character have been analyzed by me, when I found that these white spots were owing to the presence of a glass containing alumina. Now alumina raises the melting point of any glass of which it is a constituent. So, then, these white spots were due to the presence in the flint glass, which was perfectly clear, of a much less fusible glass which was only partly made when the flint glass was ready for working. On investigating the matter, it was found that the alumina came from the glass-pots, for when by my advice the faulty pot was withdrawn from the furnace and carefully examined, although it had been in work only six weeks, the bottom was honey-combed to a very considerable extent, showing that portions of the pot had been dissolved; and inasmuch as the fire-clay, of which the pots are made, contains a large quantity of alumina, it was not difficult to trace the source of these white spots which had rendered useless much very valuable glass. On inquiry it was found that the pots had been made entirely of new clay, and on reference to the book of workings, which was kept in the glass-house, it was also found that for some time, the glass-pots used in that establishment had been made of new clay, and that on a previous occasion a similar calamity had before happened.

In the records kept where pots were made, as has already been described, with a portion of old pot as well as new clay, no white spots had ever appeared in the glass. It is therefore manifest, that it is much safer to use a portion of old pot than to trust to pots made entirely of new clay.

Having considered briefly the manufacture of glass-pots, I shall proceed to the treatment of the materials to be employed. In making common window glass, ordinary sand, which does not contain any very large quantity of iron, may be used, the alkali employed being sulphate of soda, while the purifying material is either arsenic or black oxide of manganese. A small quantity of anthracite coal is added to the mixture, in order to assist in the reduction of the sulphate of soda, together with some lime. The materials are carefully mixed and placed in the furnace, where they are heated for some time, a process which is called "fritting." Its object is to perfectly dry the materials, so as to expel carbonic acid gas, which would otherwise cause swelling in the glass; but no combination must take place, to allow of silicates being formed, otherwise the alkali would melt first and attack the substance of the glass-pots, and part of it would be volatilized and lost. When this operation is completed, the fritt is put into the hot glass-pot, and submitted to the action of the heat of the furnace, until the glass is made, or "founded," as it is technically termed. In the case of sheet and crown glass, this process lasts from sixteen to seventeen hours, for it will be remembered that the top of the pot is open to the furnace, so that the flames pass over the surface of its contents. In this way the materials get heated more rapidly than when a covered glass-pot is used.

M. Gehlen gives as a good mixture for window glass:

Sand	100	parts.
Dry sulphate of soda	50	"
Quicklime	20	"
Carbon, as charcoal	4	"

Different makers have different mixtures. This by M. Gehlen is given as *about* the proportions of the several constituents employed.

The charging of the pots is conducted in this manner: they are filled with lumps of fritt, and the heat of the furnace is raised as rapidly as possible, until, in about eight or nine hours the fritt has run down or melted into glass. More fritt is then added, which also melts, and from time to time this is repeated, till the pot contains a sufficient quantity. After about sixteen hours the whole has become converted into glass, and the surface of the molten mass is covered with liquid salt and sulphate of soda. This scum is called glass-gall or sandiver, and is carefully removed with iron ladles. Some broken glass, or cullet, is now thrown into the glass-pot, a little at a time, the object being to cause any salt which may remain in the pot to rise to the surface, which is then removed, and so the glass is in this manner purified, after it has been further heated for some hours, to expel gases.

When the glass is made, and its temperature so reduced that it is in a doughy or pasty state, it is then worked off by the blowers into either sheets or tables, as is desired. The blowing of sheet and crown glass is a work of considerable difficulty and labour, and one which cannot be successfully performed, except by a workman who has been brought up from boyhood in a glass-house. A quantity of the soft glass is collected or gathered on the end of a blowpipe, and the workman then blows into it, and distends it into a globular form. Now it is necessary, in making sheet glass, that that globular form should be elongated; the workman therefore holds his blowpipe, which is about five feet long, in a vertical direction, and the softened globe becomes pear-shaped. By dexterously swinging the blowpipe from side to side, which he does while standing on a plank placed over a sort of pit, and by causing it to rise on either side, he converts the pear-shape into a true cylinder, having rounded ends. When the cylinder has assumed the exact shape desired, he places his thumb on the end of the blowpipe, and holds the opposite end of the cylinder in the mouth of the furnace. The glass softens at the heated end, and the expanding air causes it to burst the opening. It is then shaped with a suitable tool, so that it is of the diameter of the cylinder. When the latter is cooled, a piece of hot glass is applied to its shoulder with a pontee, and is drawn out into a thread around it. This makes the glass hot. The thread of glass is removed, a cold instrument is applied rapidly, and the shoulder of the blowing is cut off. The glass is next detached from the blowpipe, and its ends removed, and it is then annealed for a short time, and cut down lengthways internally by a diamond. It is afterwards placed, with the long cut uppermost, in what is called a flattening kiln, that is, in a sort of oven or furnace heated to a high temperature and having a perfectly smooth stone floor; after a short exposure the glass softens, and a workman, with suitable wooden tools, opens it out where it was cut by the diamond, and causes it to lie flat upon the stone. It is then rubbed by a wooden tool, and in this way is flattened, removed from the flattening stone kiln, and placed in a hot chamber, in which it is allowed to cool slowly, for the purpose of "annealing."

Sheet glass, formerly called broad glass, was originally made on the Continent; but its manufacture, first established in this country by the introduction of foreign workmen, has extended to very large dimensions, and the quality of English sheet is now quite equal, if not superior, to anything that is produced abroad. The advantage which it possesses over crown glass is, that much larger sheets can be made, and this is very easily noticed if we examine the larger dimensions of common window panes compared with those which were formerly made. Even now the workmen employed in this class of manufacture are generally Belgians. A sheet glass blower must be very strong, and have great skill in handling his blowpipe, for the cylinders which he blows are frequently sixty inches long, and their weight is very considerable. Glass shades are blown by sheet blowers. These sometimes are very large, and require great skill. When their shape is to be that of a cylinder with a dome top, they are made as in the ordinary course of blowing a cylinder of sheet glass, but instead of one end being burst as described, they are simply detached from the blowpipe. When they have to be oval or square at their bases, they are blown into wooden moulds of the required form, which have their insides charred. The gathered mass of glass is placed inside such a mould, and is then blown into until it touches the sides. This is an operation requiring great strength and delicacy; strength to blow with sufficient force to bring the softened glass to touch the mould in all its parts, and delicacy to prevent the pressure from being so great as to cause the outside of the glass shade to receive marks on its surface from the mould.

The shaping of the molten glass into tables of *crown* is different in detail. The globular mass formed by the first blowings is held by a workman vertically over his head. An assistant gathers a small quantity of soft glass from the furnace on the end of a pointed iron rod, and causes it to adhere to the flattened surface, at a point opposite to that to which the blowpipe is attached. The glass near the blowpipe, while hot, is touched with a cold instrument, and immediately cracks around its neck, detaching the blowpipe from the mass. The pointel is taken by the blower, and the opening formed by the removal of the blowpipe is placed opposite to what is called a "flashing" furnace, that is, a furnace with a large circular opening in its front, and which is heated to such an intense degree, that it is impossible for a person unaccustomed to it to approach within several feet of the furnace-mouth. The workman generally wears a shield or screen to protect the upper part of his body and face. The glass becomes softened by the heat, and the workman gives his pointel a rotary motion, somewhat similar to that which a housemaid gives to a mop when she trundles it; and as the glass softens, the opening gets larger and larger, until at last the softened mass instantaneously flashes out into a circular sheet, an operation which produces a very startling effect upon the eyes of anyone beholding it for the first time. The circular crown table thus made is detached from the pointel, and the mass of glass which caused it to adhere forms what is known by the name of the bull's eye. The table thus made is, like the sheet, placed in an annealing furnace, and there left for a proper length of time.

The manufacture of *plate* glass is altogether different from that of crown and sheet. First of all, much greater care is taken in the selection of the materials, the sand used being of a purer kind than that employed in the manufacture of common window glass; the alkali is of a better quality; and more caution is taken in all the manipulative processes prior to the melting of the mixture. Arsenious acid is more frequently used than manganese for the correction of the iron impurity. It has been noticed that in the plate glass-pots, there are grooves placed around their sides, and these are intended to receive metal claspers, by means of which the pot can be removed bodily from the furnace. In former times the glass was made in large pots, and then ladled out into smaller ones, of a square form called *cuvettes*, and in these it was left exposed to the heat of the furnace for a length of time, in order that it might be refined, by the rising of impurities to the surface and by the escape of air bubbles. The use of these cuvettes is now discontinued, and the pot in which the glass is founded is removed from the furnace and its contents poured upon the tables on which the plate is formed, by the action of rollers. A plate glass table is made of iron; its surface is smooth and of the size required to make a large plate, and it is placed upon wheels and run upon a tramway from one part of the glass-house to another, so as to be opposite to the mouth of the furnace from which the glass-pot has to be removed. Along the sides of this table, taken lengthways, moveable strips of iron are placed, rising above it to a sufficient height to secure the desired thickness for the glass plate, and on these strips runs a roller, so adapted that it can be made to pass pretty readily from one end of the table to the other. The contents of the glass-pot, when placed over the table by means of a crane and tilted up, fall out somewhat as a lump of dough would fall from a kneading trough if it were inverted, for it must be borne in mind that the glass in this process is not in a very fluid state. The roller is made to pass rapidly over the softened glass, and in this way spreads it over the table, until it comes in contact with the strips placed along the edge, which serve as gauges for determining the thickness of the plate. After the plate is formed, it immediately sets, and is removed while hot into an annealing furnace, which is always so placed that the glass can be transferred to it from the table with the least possible delay. In this furnace several plates of fresh-made glass are deposited, and are allowed to cool extremely slowly, in order that the glass may be properly annealed. When this process is completed, the plates are removed, the edges are trimmed off with a diamond, and one plate, bedded in plaster of Paris, is placed upon a flat stone receptacle; another plate, also coated on one of its sides with plaster of Paris, is made to adhere to a piece of machinery placed directly above the other plate, and is so situated, with respect to this latter, that the two surfaces are perfectly parallel one to the other.

It should be here mentioned, that the side of the plate which touches the table is always rough, and has no polish, while that over which the roller is passed is slightly undulating, and has a bright polish similar to that of a sheet of blown glass, and which is technically known as "fire" polish. The machine to which the upper plate is attached is so arranged that, when set in motion, it causes it to move in just the same direction that a plate would do if moved by the human arm; this is therefore called an elbow motion. Boys stand by the sides of the two plates, and throw fine sand and water on the lower one, so that the opposed surfaces mutually grind one another, and when this process is completed on one side, they are reversed, and the same operation is performed on the other side. The plates have now the appearance of ground glass, and the surfaces are further ground by fine emery powder, which causes them to be much smoother and more ready for the final polishing. Formerly this was entirely done by hand, women generally being the operators, and oxide of iron, called crocus, mixed with water, the material employed for polishing. Now, however, a more rapid and perfect method is adopted by the use of machinery. A table is prepared which moves from side to side, giving to the plate a lateral motion; and above is a beam, in which holes are drilled at intervals, through which short iron rods, nearly an inch in diameter, pass. On these are padded iron buffers, covered on their under surface with leather; while, pressing down these rods, and therefore the buffers, are springs, which act with considerable force, but which are able to yield to pressure caused by any inequality over which the buffers may pass. The glass plate is fixed upon this table, and its upper surface is exposed to the action of the buffers, while oxide of iron, in a very fine state of division and mixed with water, is allowed to come upon its surface. The glass travelling from side to side is rubbed by the buffers in a lateral direction, and has also a longitudinal motion, so that every portion of it is rubbed equally. If any inequalities occur on the glass, the springs which press down the buffers give way and allow them to rise over it, and this process is continued for some time, until at last the plate receives the polish so characteristic of plate glass. It is then removed from the table and examined by skilled persons, and whatever defects can be removed by hand, are remedied.

Another kind of plate glass, called "patent rolled plate," is made by ladling out from a pot molten glass in the proper state of consistence. The ladle is brought over a small glass table, and a similar operation is performed to that already described. This patent rolled plate is sometimes made with grooves on one of its surfaces, or with patterns in imitation of diamond quarry glazing, and, in fact, with any designs, according to the taste of the manufacturer. These designs are all engraved upon the table, and communicate their patterns to the soft glass; but the smooth surface of such glass which comes in contact with the roller is slightly undulating, though polished. This method of glass making was invented and patented by Mr. Hartley, the noted manufacturer, of Sunderland.

A lighter kind of plate glass, which is principally used for glazing the better class of pictures and engravings, and called "patent" plate, is simply sheet glass polished after the manner of plate glass. Crown glass, which only admits of being cut into small squares, is also used for picture glazing, but is more carefully prepared, and is called by the name of "flatted crown."

Looking Glasses.—Plate glass is employed for making looking glasses, and two processes are now in use for silvering them, the first of which consists in applying a sheet of tinfoil saturated with quicksilver to one side of the glass. The operation is conducted as follows: on a perfectly smooth table a sheet of stout tinfoil is laid, and on it is poured quicksilver, which is distributed evenly over the surface with a hare's foot. When the whole sheet is amalgamated with the quicksilver, more of that substance is poured over it, until it flows quite freely. The glass plate to be silvered, having been made perfectly clean, is floated upon the surface of the quicksilver, an operation requiring care, and is then covered all over with weights, by which means the excess of quicksilver is pressed out, and the glass comes in contact with the amalgamated sheet of tinfoil, to which it adheres entirely. This ancient method of silvering glass has some advantages over the one next to be described. The colour of the plate is, according to artistic taste, better, and with care the plate will not lose its brilliancy for years. I have in my possession some old glasses, the silvering of which is very beautiful, except where it has suffered from mechanical injuries. Silver can be precipitated from a solution of nitrate of silver in several ways, and in some of these specimens was like a bright film. If a crystal of nitrate of silver be put into a test-tube with some bitartrate of lime, and the mixture be rendered ammoniacal and gently warmed (it being kept in motion during the experiment), its sides will be covered with a very brilliant deposit of metallic silver. Oil of cloves and grape sugar have also the power of reducing metallic silver from ammoniacal solutions of the nitrate, when gently warmed; but the mixtures must not be made too hot. In silvering plates of glass, they are first well cleaned, then placed in a perfectly level position, and the silvering liquid is poured over the surface, the room in which the operation is performed being kept sufficiently warm to assist the deposition. When enough silver has been deposited on the glass, the liquid is poured off and the plate dried, while the silver film is protected by being coated with a suitable hard varnish. The composition of the mixtures used by different persons is generally kept secret, though the chemical principle of the reduction of the silver salt is the same. Glasses silvered by this process sometimes lose their brilliancy, by becoming covered on their silvered side with small spots. It is however stated that this results either from a bad system of deposition, or from the film of silver not being sufficiently thick and solid.

Flint Glass, although called by this name, is not made from flint, but from the best sand, of pure and dazzling whiteness, obtained from Alum Bay, in the Isle of Wight, and from Fontainebleau, in France. The cost per ton is from 1*l.* to 1*l.* 15*s.*, whereas the price of the sand used for making plate glass is about one-eighth of that amount. The alkali employed is generally extremely good carbonate of potash, whereas soda is used in the manufacture of the other kinds of glass which have been described. The addition of a small quantity of black oxide of manganese is sometimes necessary to correct the slight tint imparted by iron, which seems to be always present in minute quantities, even in the purest samples of sand. Oxide of lead in the form of red lead, in this sort of glass, takes the place of lime. The advantages derived from using the oxide are, that it makes the mixture more fusible, and also imparts that particular brilliancy and lustre so peculiarly characteristic of well-made flint glass. In different works, various mixtures are made for the composition of the glass; but to give an idea of the proportions in which the materials are mixed, it will be well to quote the statement of M. Payen, who says that of the finest crystal flint glass, the following is the composition: sand, 3; red lead 2 to 2¼; carbonate of potash, 1½ to 1-2/3. A little nitre or saltpetre is used as an oxidizing agent. The glass-pots employed in this branch of the manufacture are covered, so that the flames of the furnace do not come in contact with the materials, the object in thus isolating them from direct contact with the flame being to prevent the entrance of impurities, by which the colour might be injured. On account of the pots being covered, the materials take a much longer time to get hot, and require quite double the time in founding that sheet or plate glass does; the presence of oxide of lead materially assisting the rapidity of the fusion. When flint glass is ready for working, the time required to work off a pot of it is much longer than that which is required for a pot of crown or sheet; and it is a matter of considerable importance, that the furnace-man should so manage his fires as to keep the glass in a proper working condition, that is, he should not let it get too cold (therefore too solid) nor too fluid. Flint glass is worked off by the blower into wine-glasses, tumblers, decanters, and other suitable vessels. Let us take a wine-glass as an illustration of the method of working. A small quantity of glass is gathered on the blowpipe, which is much smaller than that used in making sheet, and is blown into a bulb, which may be slightly elongated or globular, the forms being given to it by the motion which the workman imparts to his blowpipe while he is blowing, or after he has blown, into the mass. In the case of a wine-glass, an assistant boy gathers a small quantity of glass on the end of a small pointel, or solid iron rod. This is placed on the side of the globe opposite that which is in connection with the blowpipe, which is then detached by touching the glass nearest it with a piece of iron, wetted with cold water: this causes a crack, and a gentle tap causes separation. The workman then moulds the opening made by detaching the blowpipe, in order to do which, he has to apply the glass often to the mouth of the furnace, to soften it. He then opens out the globe into the shape of a cup with a pair of small iron tongs, with legs uniform in shape, slightly tapering and smooth, and he uses a peculiar kind of scissors for trimming the edges. The other parts of the glass are moulded with the tongs, accuracy of size being obtained by means of measuring compasses and a scale. The workman sits during this operation in a seat with arms, laying the pontee on them, and turning it, so as to make it move backwards and forwards with his left hand, while with the tongs in his right he gives the glass the desired form.

Before passing on to a description of the manufacture and composition of coloured glasses, it is necessary that I should make a few remarks on the difficulties under which our English glass makers labour, owing to not paying sufficient attention to the scientific treatment of their mixtures. It has already been stated that glass is composed of a mixture of silicates, which are definite chemical compounds. Some are much more dense than others, and are therefore liable to sink, so that the glass taken from one part of the pot will be very different in composition from that taken from another part; besides this, it is found on examination, that other portions of the materials employed are present in such proportions, that they cannot possibly exist in the form of true silicates. M. Dumas, the distinguished French chemist, asserts, and with truth, that glass ought to be a true chemical compound. This, however, does not seem to be the opinion here; and sufficient attention is not paid by English manufacturers to mixing their materials, so as to form definite silicates, the result being that glass is produced with a striated effect. This is easy to be seen in the common kinds, as in bottle glass; but owing to the more careful and prolonged fusion of the finer varieties, such as plate glass, this defect is to a considerable extent remedied, though not altogether overcome. In the French manufacture of plate glass, more attention has been paid to the chemical composition of the various silicates which enter into it. At St. Gobain, a plate glass, is produced which, on analysis, is found to contain definite silicates, and without any excess of material which does not enter into chemical combination; and the consequence is, that this glass is more perfect and homogeneous than that made in this country. No doubt this superior quality is owing to the fact, that the famous chemist, Gay-Lussac, devoted much of his time to assisting in the manufacture carried on at these works. We cannot over-estimate the importance of a scientific superintendence, not only of glass-works, but of all other manufactures in which chemical reactions take place; for although experience may lead a cautious observer to produce substances of nearly correct composition, yet the assistance of a scientific observer is of the greatest importance, because, what under other circumstances must be simply empirical, is under his guidance carried on according to definite and fixed laws.

Mention has already been made of how, in the case of mixing carbonates of soda and potash, the one assists the fusibility of the other, and this is more particularly true in the mixture of silicates in the composition of the ordinary glass. Silicates of soda and potash are separately much more infusible than a mixture of the two, and the addition of other silicates to them renders them more fusible still; silicate of lead, as has already been mentioned, causing the glass into whose composition it enters to fuse at a much lower temperature than it would do if that silicate were absent. Again, if the silicate of lead be present in too large proportions, and if great care be not taken in the manufacture of lead glass, the silicate of lead, from its greater density, will sink lower among the molten silicates, and will therefore cause a larger proportion of lead to be in the glass at the bottom of the pot than there is at the top. We often notice in tumblers and decanters of the cheaper kind, that there are very distinct striæ running through the whole substance in some particular portion of the glass. Now this is owing to the greater density of the lead silicate, which sinks lower down in the collected mass of glass, and therefore imparts to it this peculiar effect. When a pot of flint glass is worked off, that which remains at the bottom usually contains more lead than that which is worked off in the earlier part of the day.

Coloured Glasses.—It has been before shown that silica unites with metallic oxides; in fact, glass is nothing but a compound brought about by the union. With certain metallic oxides, silica forms coloured silicates or glasses; and these, when fused with colourless glasses, impart to them the colour of the silicate. Oxide of iron colours glass either green or yellow, according to the nature of the oxide; the silicate of the protoxide of iron being green, and that of the peroxide, yellow of a slightly brownish tint. Copper forms two oxides, the suboxide and the protoxide; the suboxide colours glass red, while the protoxide renders it green. Black oxide of manganese colours glass purple; but if large quantities be used, it makes it perfectly black. Sesquioxide of chromium imparts a beautiful green colour to glass, while oxide of uranium produces an opalescent effect of yellow with a tinge of green. This latter, by the way, has the power of reducing the ultra-violet rays of the spectrum to luminous rays, and, when held in the rays of a spectrum obtained by the electric light, produces an extremely beautiful effect, which is called fluorescence. A small quantity of the oxide of gold tints glass pink, but the colour becomes extremely rich and ruby-like, when a larger quantity of the oxide is employed. Oxide of cobalt in very small quantities yields, with silicic acid, an intensely blue silicate. This substance, carefully prepared in a special manner and ground to a fine powder, forms the well known water-colour pigment called smalt. Oxide of silver stains glass from a delicate lemon tint to a deep orange, in proportion to the quantity of the oxide employed.

With the exception of the last-named colouring material, the above mentioned are mixed together with the substances which form the glass, and are melted in the usual way in glass-pots, except that they are treated with considerably more care, in order that their tints may be true. Oxide of silver, however, is never mixed with the materials of which the glass is made, but is applied to the surface in the following manner: a solution of nitrate of silver mixed with some substance, such, for instance, as chalk, may be painted upon the parts of the glass which it is desired to stain, and these are heated to a dull red heat, in what is called a "muffle." Wherever the oxide of silver, which is reduced from the nitrate by heat, comes in contact with the glass, the latter is stained more or less intensely, according to the quantity of silver present. Pure metallic silver may be melted with metallic antimony, and the mass ground to a fine powder in water. This powder, after being mixed with some Venetian red and gum water, is applied to the surface of the glass, which is, when dry, heated to a dull red heat in a muffle, producing the yellow stain, which can be seen after the Venetian red and the excess of silver have been scraped off. The reason why silver, or oxide of silver, is not mixed with the glass materials and fused with them, is because it does not readily unite with oxygen, and, when it has done so, it loses its oxygen again at a high temperature, and becomes reduced to the metallic state; and inasmuch as metals have no effect whatever in staining silicates, glass made in this way would not have the yellow colour which it has, when the silver is heated upon its surface to a much lower temperature in a muffle; for the temperature to which the constituents of the glass must be heated, so as to cause them to burn it in, would be so high, that the oxide of silver first formed at a lower temperature would be reduced to the reguline or metallic state. Gold also, like silver, does not unite with oxygen readily, or remain in union with it at high temperature; therefore great care is required in the preparation of glass to be coloured by oxide of gold; the form in which it is used being generally that of the purple of Cassius, made by precipitating a salt of tin with a salt of gold. This substance is mixed with the glass to be coloured, and heated in a suitable glass-pot. Portions of it are gathered and allowed to cool, these being generally of a yellowish, brownish, and sometimes reddish tint, though they have not in any case the same beautiful red colour which they produce when applied, as will be immediately described, to the surface of white glass. A certain quantity of white glass is gathered from the glass-pot in the soft state with one of these pieces of gold glass; the whole mass is heated until both become soft, and is then blown and formed into sheet, which, on examination, will be found to consist mainly of white glass, with its surface thinly covered with the glass stained with oxide of gold, while the beautiful ruby colour, which the gold imparts to the glass, appears pure and distinct. If such glass as this be heated to too high a temperature, as when it is used in the manufacture of stained glass windows, the ruby colour is in part, and sometimes altogether, destroyed, for the oxide of gold loses its oxygen, and metallic gold is left behind, which does not yield a colour to the silicate. I have in my possession a piece of French glass of a pale sapphire tint, which, when heated in the oxidizing flame of the blowpipe, assumes a brilliant and intense ruby colour, showing that in the first condition, the gold is not in a state of oxidation sufficient to impart colour to the glass.

When the suboxide of copper is mixed and fused with the glass which it is intended to colour, the result is an opaque substance, almost like red bottle-sealing-wax, which is treated in a manner exactly similar to the gold glass; viz. it is coated with white glass, and blown and shaped into sheets, which owe their intense ruby colour to a thin film of the coloured glass closely adhering to the mass of the white upon which it is placed. Glass made in this way is called "coated," and sometimes "flashed" glass, and is extremely useful for ornamental purposes, for by the action upon the coloured surface of hydrofluoric acid, the ruby coating can be eaten away, and the white glass beneath left entire. If the backgrounds of the patterns be painted upon the ruby side with a material like Brunswick black, which is able to resist the action of hydrofluoric acid, and if the plate of glass, on its ruby side, be exposed to the action of the vapour of this acid, or to the action of the acid in solution in water, in a short space of time the pattern will be eaten away; and if the Brunswick black coating be removed with turpentine, a sheet of ruby glass will be obtained with a white pattern etched upon it.

Owing to the powerful colouring properties which oxide of cobalt exerts, a very deep-coloured blue glass can be made, which can be treated like the red copper glass, and may be made to coat and cover in the same way the surface of plates of white glass. Purple glass, coloured with oxide of manganese, and green glass are also sometimes used as coating materials for white glass, but other colours are never employed in this way.

It is manifest that if different metallic oxides be used with the same glass, mixed tints will be produced, so that by mingling small quantities of oxide of cobalt and protoxide of copper, a blue glass having a greenish hue may be obtained. The revival of glass painting has caused manufacturers to turn their attention to these mixtures, in order to produce tints resembling those of ancient stained glass. Messrs. Powell and Son, of Whitefriars, were the first to perform experiments on these mixtures, and after much laborious attention and patience their efforts have been crowned with great success, for they have been enabled to produce glass as beautiful in tint and in texture as the best specimens of ancient manufacture. Their example has been followed by others, such as Messrs. Hartley of Sunderland, and Messrs. Chance and Co. of Birmingham.

While treating of the effect produced by different metallic oxides upon colour, it may be well to mention that the opaque glasses used for such purposes, as the enamelling of watch-faces, are made by mixing with the materials a certain quantity of arsenious acid (or white arsenic), in much larger quantities than when it is employed simply to correct the tint imparted to glass by the iron impurities in the sand. Oxide of tin also renders glass white and opaque, and a certain quantity of bone ash will produce a similar effect, though not in so satisfactory a manner.

Glass painting first became general in this country at the time when the Early English style of architecture prevailed, and some of the best specimens were executed during that period. By the best specimens is not meant, that the figures painted upon those windows were artistically as correct as similar works of a later date, but that they were designed and executed in accordance with those principles, which should always govern the adaptation of a substance like glass to ornamental purposes. The earlier mediæval artists depended for effect more upon the boldness of their outline, than upon the intensity of their shading or the delicacy of their manipulation. The form of a thirteenth-century figure is merely indicated by a few bold and well drawn outlines, the features being formed by lines, the pupils of the eyes by simple well-shaped masses of opaque pigment; and such a treatment as this was quite sufficient to convey what was, to the observer, more or less a symbolical, than a truthful representation of the Scripture history which they were intended to illustrate. These artists remembered that windows are openings in a building, through which light has to pass, and they did not, therefore, like many of the later imitators, render them opaque by masses of intense shadow, which perfectly obscure the colour of the glass upon which the picture is painted, and render the passage of light through it simply impossible. The thirteenth-century glass painters, too, in the treatment of their shadows, bore this great principle in mind, and instead of daubing and stippling them on, usually indicated them with a thin wash of enamel colour, intensified in parts by lines crossing one another, and therefore called cross-hatching, through the interstices of which the light, although subdued, was able, in a measure, to pass.

But as the object of this article is not to discuss the merits of the various styles of glass painting, however much I might desire to enlarge upon it, I pass on to a description of the methods employed in the manufacture of stained glass windows. In the first place, after a design has been drawn, in which the effect of the window as a whole can be carefully considered, cartoons of the figures and ornament are made of the exact size of the intended painting. And here it should be noted, that all the lines should be extremely clear, precise, and well drawn, because it is from these that the workman, who is not usually himself an artist, has to convey on the glass the feeling of the artist. The cartoon, when completed, is laid down in pieces for convenience-sake on a table, and fastened with small nails. The glass-cutter then selects the various coloured glasses which are required to be inserted in their proper places, so as to carry out the design of the artist. For instance, a piece of white or yellow-tinted glass is cut to the shape of the face. If the figure be a small one, the hair also is included in this; and probably in the figure of a saint, the nimbus which surrounds the head may be included; while in larger figures, particularly in the earliest styles, the face was of glass of one tint, the hair of another, and the nimbus of one or more tints, different from either of these. Sometimes, in the later styles, the hair, after the face was painted and burnt in, was stained with the silver stain already described, so that when the glass was cleaned, it was of a yellow colour. However, not to enlarge more upon these points, which really belong more to the artistic than to the industrial part of window painting, let us proceed to the consideration of manipulative details. The outlines of the figures and ornament are painted with a substance called "tracing brown," made by mixing with a flux some oxide of iron, heating them together in a crucible and grinding the product to a fine powder, which is mixed with certain vehicles adapted to the particular use to which it is to be applied. Different fluxes are employed by different glass painters; some contain borax, because such fluxes fuse more easily, and therefore cause the glass which is painted to be exposed for a less time, and to a lower temperature, than when less fusible fluxes are used.

It is always satisfactory to an author, to feel that his articles have been of some use to those whom he hoped to benefit. Since this article was written a letter appeared in one of the architectural journals, complaining that the glass furnished by manufacturers to glass painters was of inferior composition to that which was used by the manufacturers of ancient stained glass windows. In fact, it was asserted that modern glass was not made with due care, and that to this was owing the unfortunate disappearance of some of the painting and tracing of modern stained glass windows; but that this is not the case, is manifest to all who understand the manufacture of glass. The real reason why the colouring matter with which glass painters outline and shade their designs, has in many instances gradually come off from the surface of the glass, is, because the fluxes used for making it adhere to the glass are of such a composition, that they themselves have by the action of time become disintegrated.

Some time ago, a person engaged in the manufacture of the enamel plates used for railway lamps, on which are written the names of the stations, called upon me, and told me, that the enamel which he employed had become dark, spotty, and in many cases had peeled off from the glass. The reason of this is identical with that which occurs in stained glass windows, viz. that the fluxes that he used were not suitable for the purpose, considering that they had to withstand the action of the weather. From an analysis made of these fluxes (not of those last alluded to, but of those which have been employed in stained glass windows), it appears that large quantities of borax have been introduced; and, wherever this is the case, no reliance whatever can be placed on the permanency of pictures painted with such fluxes. I have appended a few receipts for fluxes, which can be used with safety by any glass painter who will take the trouble to try them. But I must strongly advise that all those who are connected with the making of fluxes in any glass painting establishment, should master sufficient chemical knowledge to enable them to ascertain the behaviour of the materials, with respect to one another, as well as of the nature of the glass upon which they are employed; for very much indeed depends upon a correct knowledge of the character of the glass as to whether it be hard or soft, what it contains, and of the temperature at which the glass becomes sufficiently soft to form a firm and enduring union with the colours fluxed upon it.

Receipts for Fluxes.

	1.		
Flint glass (powdered)	10	parts. }	moderately hard.
White Arsenic	1	" }	
Nitre	1	" }	
	2.		
Red Lead	1	" }	soft.
Flint glass (powdered)	3	" }	
	3.		
Flint glass	6	"	
Red Lead	8	"	

(Mixed with four parts of the first flux, soft.)

The use of very soft fluxes is attended with this inconvenience, that the boracic acid contained in them is generally acted upon by moisture and becomes hydrated, and in this condition often causes the painting to peel away. Harder fluxes, although they have the disadvantage of necessitating the glass to be submitted to a much higher temperature for a longer time in the kiln or muffle, are the best, and, with judicious management, can be used without any injurious consequences to the work on which they are employed. Lead fluxes, containing oxide of lead, are sufficiently fusible for all ordinary purposes, and are not liable to the same objection as fluxes containing borax. Suppose, then, it is desired to paint the outlines of a face, the glass is cut to the shape of the face in the cartoon; it is then laid upon it, and the painter, seeing the lines through the glass, is able to trace them with his brown paint upon its surface. He generally uses gum water as his vehicle, and puts on the shading also with the same mixture, though sometimes it is found necessary to use a substance which is not affected by moisture, as for instance, tar-oil. It is impossible, in the short space of this article, to indicate those occasions on which one should be used in place of the other; a knowledge of this can only be obtained by consulting authorities in which details are more minutely given, or by watching the operations of the glass painter in his workshop. When the face is finished, it is removed, and another portion of the figure, say a piece of the drapery, is proceeded with in exactly the same way; and so, by a repetition of this process in all parts of the figure, it is completed, and looks very much like a puzzle, the parts being put together on the cartoon before the work is finished, in order to see that the whole is harmoniously treated. In shading the face, hands, and those parts of the drapery which require it, a glass easel is used, on which the figure is put together, and the parts made to adhere by wax, so that the artist is able, while painting, to form an idea by transmitted light of the effect which will be produced when the window is finished. The ornament is painted in a similar manner, but usually not with the same care in the details of its execution.

When all the glass is painted, it is fired in a muffle, upon the proper construction of which a great deal depends. It is usually made of iron, and should not be more than 15 inches from its bottom to the top, though its width may vary. It is never well to have muffles for firing glass for painted windows larger than about 2 feet wide, by 2 feet 6 inches deep. The top of the muffle is usually slightly arched from side to side, and it is placed in the furnace on a tolerably thick stone floor, so that the bottom may not get too hot. The fire, which is lighted below, is allowed to play up its sides and over its top, the flue being so built as to draw the flames in that direction, for a top heat is the best heat for firing glass regularly. The muffle is arranged with ridges in its sides, passing from front to back parallel to one another on one side, and exactly opposite to corresponding ridges parallel to one another on the opposite side. These metal ridges are intended to receive iron plates, and there is generally about an inch or rather less between the top of one plate and the bottom of another, when the muffle is perfectly filled. The plates are covered over with perfectly dry powdered chalk or whiting, and the pieces of glass are laid upon them with their painted sides uppermost. When the plates are charged, they are put into a muffle with an iron door, in the centre of which is a hole, and a conical tube with the base attached round it. It is larger than the opening at the other end, which projects some 6 or 7 inches from the surface of the muffle-door at right angles to it. A second door is then placed at a short distance from the first, the tube passing through a hole made for the purpose in it. The orifice is usually stopped by a piece of fire-clay, which can be removed at pleasure. The use of the tube is, to enable the manager of the kiln to look into the muffle, from time to time, to see that the glass does not get too much heated. When the firing is completed, the fire is raked out and the muffle is allowed to cool very slowly, and by this process the glass becomes annealed.

When it is desired to apply to any portion of white glass some yellow silver stain, this can be done either in the first firing, by floating it on to the places to be stained, and allowing it to run in a sort of stream from the brush, so that it will evenly cover the surface and cause the heavier portions of the stain, namely, the mixed metallic silver and antimony, to sink regularly to the bottom, and come fairly in contact with the glass. Not very long ago, it was mentioned to me by a glass painter of note, that the workmen much prefer using the old stain made with silver and antimony, to that which is produced by using nitrate of silver. This really is a mistake on their part, for, when properly managed (and the knowledge of how to manage this stain can be acquired with very little trouble), the nitrate of silver stain is by far the best, and produces much better tints, with less chance of what the men call sulphuring when the glass is fired. This sulphuring is simply the result of opacity, obtained by heating the glass to too high a temperature. If the staining is to be performed in the same firing as that by which the painting is to be fixed, it is quite clear that the outlines of the part to be stained must be painted in, with tar-oil, or with some such substance which is not affected by the moisture of the stain. However, in general, the staining operation is performed after the first firing, that is to say, those pieces of glass to which the silver is to be applied are stained in the method above described after the first firing, and are then fired again, because the heat required to produce a good stain from silver is of a somewhat different character from that which is required simply to fuse the flux that binds the pigment to the glass. A longer and less intense heat, technically called a "soaking," is the best for producing an even and pure yellow tint. If the temperature be allowed to rise too high, the oxide of silver, which alone can stain the glass, gets reduced wholly or in part, and when this happens to only a slight extent, it destroys the transparency of the stain; and when it happens to a great extent, it destroys its colour altogether, making the glass opaque.

It is a matter of astonishment to me that glass painters do not use a ruby stain, which, with a little practice, can be managed quite as successfully as the yellow silver one. It is true that it would be impossible to fire the ruby and the silver stains together, and it would not be at all convenient to fire the ruby stain at the first firing of the painted glass. The method of staining ruby is as follows: grind up carefully some black oxide of copper, mix it with water (or with a small quantity of gum added), float it on the parts to be coloured, place it in a kiln and heat it. Black oxide of copper, when mixed with glass and melted in a glass-pot, makes the glass green; suboxide of copper, which contains less oxygen than the black oxide, when treated in the same way, makes it red. Now, if it can be reduced to the lower oxide of copper, while the black oxide of copper on the surface of the glass is heated, it will then colour the glass red. The best way of reducing the black oxide, is to connect the muffle with a gas-supply pipe, and allow coal gas to pass during the whole time that the heating process goes on. The action of the gas, which contains hydrogen and carbon, is to take away oxygen from the black oxide of copper, when it is at a high temperature; and, as soon as sufficient is taken away by the hydrogen to reduce the black oxide to the state of suboxide, it stains the glass red. It does not matter if the reducing action be continued longer, so that the oxide of copper be reduced to the metallic state; for at that temperature, the stain produced by the red oxide of copper is not removed by the continued action of hydrogen gas. The employment of this process would certainly enable artists who paint in the later styles of glass painting, to very much enrich their draperies, and to produce, more easily, effects which now can only be obtained by a complicated system of lead-work.

When the pieces of glass which have been fired are perfectly cold, the next process is to unite them altogether by peculiarly shaped strips of lead, which are of various kinds, according to the character of the subject required. The lead has a thick part or core, and at right angles to the top and bottom of this are thin plates called the "leaves." The core is milled with little ridges running at right angles to them, so as to enable the workman to bend the lead about with facility. The edges of the piece of glass to be leaded are placed between the leaves and resting upon the core, and the lead is thus arranged all round the glass, and is then laid in its proper situation upon another cartoon, prepared from the one from which the figure was painted, and indicating simply, by lines, where the lead-work is to come. The first piece is fixed by means of nails temporarily placed through the lead. Those pieces which touch it in the design are put in their proper positions, so that the edge touching the next piece will be underneath the opposite leaves to those which confine the first. This operation is repeated, till all the parts of the design are surrounded by lead, and by it united to one another; the joints being secured by solder, generally applied by gas. Nothing now remains but to fill in the interstices between the lead and the glass, so as to make the window firm, solid, and water-tight; and this is done by rubbing into them with a scrubbing brush a cement, usually made of white lead, oil, and plaster of Paris. This composition varies in different stained glass works, nor is it material, provided that the substance hardens, does not crack, and is waterproof.

From this description it will be seen, that the various colours in the different parts of the window are put in as pieces, and that no colours, properly so called, are applied by the brush to the surface. There are, however, certain tints of the "tracing brown," which can be obtained by the addition of black oxide of manganese, or by a different method of preparation of the oxide of iron, to give it its body. Sulphate of iron, when heated, loses its sulphuric acid, and the oxide, which was, as sulphate, in the state of protoxide, becomes, by heating, the red or peroxide of iron; its tint, when made in this way, being generally lighter than the tint of that form of oxide which is employed as ordinary tracing brown. It is sometimes called flesh tint, though this is decidedly an objectionable name for it.

It has been suggested to me, that I should give some receipts for the manufacture of the enamel colours used in mediæval glass painting; I have therefore added a few which are easily prepared. Others of a more complicated nature had much better be obtained from the makers of the enamel used in porcelain painting. And here again, let me remark, that in ordering fluxes from these manufacturers, it should be stated especially that a flux is required which does not contain borax, nor should the painters in any establishment be allowed to use these softer fluxes, which they are almost certain to do, unless forbidden; for though they are easier to work with, they will infallibly lead to calamitous results.

	Yellow.	
Oxide of tin	2	parts.
Oxide of antimony	2	"
Red Lead	16	"
	Orange.	
Red Lead	12	"
Oxide of antimony	4	"
Persulphate of iron	1	"
Flint powder	3	"
	Brown.	
Black oxide of manganese	2·25	"
Flint slate (powdered)	4·0	"
Red lead	8·5	"
	Brown Red.	
Crocus (oxide of iron)	3	"
Green sulphate of iron (calcined) mixed with six parts of these No. 2.	1	"
	Light Red for Flesh Tints.	
Carbonate of lead	1·5	"
Persulphate of iron (calcined)	1	"
Flint glass	3	"

The use of enamels—that is, substances which impart various colours to the glass, when placed on its surface by their fusion—is not admissible in windows which pretend to belong to any of the earlier styles of glass painting; though enamel painting is used for the decoration of houses, and sometimes, as I consider very improperly, for the decoration of church windows. One sheet of glass, colourless and transparent, or it may have its surface ground, is usually employed. A subject is painted on it with enamel colours, much as subjects are painted upon porcelain. When the work is completed, the glass plate is fired, and thus the colours become semi-transparent, and perfectly adherent to the plate; but they are not clear and bright, and transparent, as are the colours of glass which is coloured in the pot, and therefore have not the same brilliancy, nor do they allow of the same bold and effective treatment.

It is much to be desired that amateurs who can draw, and who have a feeling for this particular style of art, should devote a portion of their time to its execution. They will find it to be extremely agreeable and pleasant, and the few difficulties which they meet with in their first attempts will be readily overcome by perseverance, or by applying for assistance and advice to gentlemen engaged in the pursuit of this interesting profession.

Moulded and Cut Glass.—Flint glass is now very commonly blown in moulds, and this art has been brought to such perfection that moulded decanters and tumblers have an appearance very similar to that of cut glass. The moulds are always made of metal, and so constructed, that they open out into two or more pieces, which are generally hinged to the bottom of the mould. The workman places it on the ground, and fixes it by standing on projections from its side. He then gathers a suitable quantity of glass on the end of his blowpipe, which he places in the mould, and the side of the glass touching it will thus have impressed upon it whatever form is engraved on it. After the glass has become hard, the mould is opened, and the glass vessel is removed and annealed.

When it is desired to cut a design on the outside of a tumbler or wine-glass, the vessel is, in the first instance, blown of a thicker substance than if it is to be left uncut. The necessary shapes, which are usually in facets, are cut upon it by the action of sand and water, a lathe of a very simple construction being used to give a rotary motion to cutting discs, made of stone and kept continually moist by water dripping on them, so that when the glass is pressed against them, the required portion of its surface is worn away. The usual diameter of these stones is about 10 inches. After the rougher stone has been used, a finer kind of sandstone disc is employed, or a disc of slate, upon which sand and water are allowed to drop, and the already roughly cut surface is, by their action, partly polished. Copper discs with flattened circumference are used for polishing the glass, and for this purpose, emery mixed with oil, is applied to the edges of their circumference.

Ground Glass is made by rubbing the surface of glass with sand and water, just as in the first operation of plate glass polishing. But a very ingenious method is now generally adopted for grinding glass, by placing it in a cradle, so that it can swing from side to side; sand and water are placed upon the glass, and it grinds itself, so to speak, by this operation.

Annealing and Devitrification.—As the word "annealing" has been often used in this article, it will be well to explain what is its action. If a piece of molten glass be dropped into water, it will assume an oblong shape, the lower end of which will be round, while the other will taper off into a fine point. These drops, which have received the name of Prince Rupert's drops, look like pieces of ordinary glass, and if the small end of one of them be broken off, a sort of explosion takes place, and the whole mass flies into a thousand minute pieces, some of which will be found to have been driven to a considerable distance. Here then it appears, that when the skin, which is perfect and entire in the Rupert drop, is broken, the bond which held together the constituent particles is broken also, and so they are acted on by a repellent force, and fly away from one another. If hot water be poured into a thick common tumbler, it very generally cracks it: but if the tumbler be thin and of better manufacture, it will bear almost boiling water without cracking. In the first case it has been badly annealed; and besides this, glass being a bad conductor of heat, from its thickness, the heat imparted by the hot water expands the inner surface, while the outer coating, not being warmed, does not expand, and, retaining its original form, is burst. If, however, a tumbler be thick and properly annealed, there is not so much danger of its breaking, when a portion of it is exposed to a considerable rise of temperature. In the case of the Rupert drops, they are not annealed at all, and so there is no cohesive bond between the particles, such as there would be if they were properly annealed, that is, if, instead of being cooled suddenly from the molten state, they were allowed to cool in a heated chamber very slowly. After glass has been heated, the particles of which it is composed take a long time to rearrange themselves, so that in the manufacture of thermometers, it is necessary, after sealing up the bulb and tube which contain the mercury, to allow them to remain for a long time; otherwise the pressure of the air on the outside of the bulb, not being supported by any air on the inside, causes the particles of glass to become more compact, and thus renders the capacity of the thermometer bulb and tube smaller than it was, when the thermometer was first sealed. It seems that the process of annealing glass gives time for the particles to arrange themselves in such a way, that when the glass is cold, it will not be so liable to fracture from sudden changes of temperature.

Considerable curiosity has been excited of late by a new invention, which has resulted from the investigations of a Frenchman. We have been told that tumblers and wine-glasses, and other glass utensils, could be so treated that they would never break; and experiments performed upon many samples of these glasses led one to suppose, that the object had been attained. There is no doubt whatever, that some who have had experience of what is termed toughened glass know, that in many cases very uncertain results are obtained in the resisting power of the glass to the action of a violent blow. Before, however, entering into some researches which I have made on the subject, it will be well to state what is the nature of the change which the toughening process produces in the glass, and this seems to be a fit place for this consideration, as the method of making, and the behaviour, of Prince Rupert's drops, have just been discussed.

The physical properties of these Rupert's drops have been examined with great care by M. Victor de Luynes, and the results of his experiments have been communicated to the *Société de Secours des Amis des Sciences*. For the purposes of this article, many of his experiments have been repeated, confirming in general his observations, and others have also been instituted. The toughness and hardness of these drops are remarkable; the thick pear-shaped portion will bear a sharp stroke with a hammer without breaking; nor can it be scratched with a diamond. To break the tapering thread or tail, as it may be conveniently called, requires considerable force. To find out what weight was required to do this, a series of experiments was performed, the results of which are given in the table following. The tail of a drop was placed over a small hole bored in the top of a table; a hook was then adjusted round a part of the tail which measured 19 on a Birmingham wire gauge; below the table and attached to this hook, a scale-pan was hung. This pan was then carefully loaded, all shock being avoided, until the thread was ruptured and the weight required to effect this was then noted:

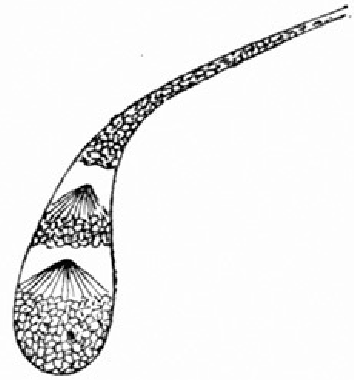
White Glass Rupert's Drops.

Gauge.	Strain.			
19	16	lb.	0	oz.
19	15 ½	"	0	"
19	16	"	0	"
19 (poor)	9 ¼	"	0	"

Green Glass.

Gauge.	Strain.			
19	18 ¾	"	0	"
19 (poor)	9	"	0	"
19	28	"	6	"
16	26 ¼	"	0	"

It will be observed that the drops made from green bottle glass withstood a greater strain than those made from crown glass; the latter, in fact, did not break throughout their mass, but left a portion of the bulb unbroken, showing some fault in the tempering. It was with difficulty that the workmen could be induced to make drops out of this kind of glass, as they knew by experience that they usually failed to break perfectly, and they stated that it was quite impossible to make them with lead glass. To ascertain what force was required to fracture a thread of like dimensions that had not been tempered, one of the drops was heated to redness, and annealed by allowing it to cool very gradually. When subjected to the same trial, it was fractured by a weight of 12 ozs., and the drop did not break into small fragments, but behaved exactly like ordinary glass, thus showing that the glass had been *un*tempered by the heating process. A piece of glass rod, drawn out into a thread in a gas flame, when subjected to the same conditions, bore a strain of 10 oz. A sewing-needle of the same thickness was broken by a weight of 3 lb. 14 oz., thus showing that the tail of the Rupert's drop was very much manner as to allow the tail to dip into hydrofluoric acid, it is found, that when the surface or skin is eaten away to a certain depth,



broken. In whatever way fractured, the particles, when examined by the microscope, show a crystalline structure, and do not at all resemble pieces of ordinary glass; when rubbed between the palms of the hands, they do not cut, nor scratch, nor penetrate the cuticle. If a drop be enclosed in plaster of Paris so as to leave a portion of the tail exposed, it may then be broken and all the particles will remain *in situ*. On removing the plaster, it will be found that the drop has been broken up into thousands of minute needle-shaped particles arranged in cones, the apices being in the direction of the tail. It would appear then from these experiments, and from observations with polarized light, that the glass in the interior of a Rupert's drop exists under enormous tension, and that it is only prevented from bursting into fragments by the outer skin; on its being broken in any part, the bond which holds together the constituent particles is broken also, and so, being acted upon by a repellent force, they fly away from one another. There is another kind of toy resembling in some respects the Rupert's drop, known as the Bologna bottle or philosopher's flask. It has the form of a soda-water bottle with the neck cut off, the bottom being rounded off and very much thicker than the walls. These flasks are sometimes formed accidentally in glass-works by the workman, who, in order to examine the quality of the glass, takes out a portion from the pot on the end of his blowpipe, and blows a small quantity of air into the mass, manipulating it in the usual manner. Whilst still at a very high temperature, it is detached from the blowpipe, and is probably allowed to fall on the ground in a place where there is a current of cold air, the exterior thus becoming suddenly chilled. When cold, these flasks will bear very rough handling, and will withstand the blow of a hammer on the outside, it being almost impossible to break them by striking the bottom; the interior will also bear the blow of a leaden bullet falling into it from a considerable height, but if a few grains of sand be allowed to fall into it, or if the inside skin be slightly scratched, the mass splits into fragments in the same manner as a Rupert's drop. The examination of these curious phenomena leads us to the subject of "toughened glass," as it has been termed. The invention of rendering articles of glass less fragile, which has given rise to so much public attention during the last year, is due to M. Alfred de la Bastie, a French engineer. His process consists in heating the glass to be toughened to a temperature close upon its softening point, and then plunging it into a bath of oil, or into a mixture of oleaginous substances kept at a much lower temperature. When this operation is successfully performed, the glass acquires properties very similar to those of Rupert's drops; it becomes much less fragile than ordinary glass, but when sufficient force is employed to fracture it, the whole flies into small pieces. It cannot be cut with a diamond, but is immediately disintegrated when the outer skin is scratched to a certain depth.

It is to be observed, however, that in particular cases it is possible both to saw and pierce the toughened glass. M. de Luynes reports, that when a square of St. Gobain plate glass that had been submitted to the process of tempering was examined by polarized light, it showed the appearance of a black cross, the arms of which were parallel to the sides of the square. The glass was sawed in two, along the line of the stem of the cross, without causing fracture. On examining the divided glass with polarized light, black bands and fringes of colour were observed, which, by their position, proved that the molecular condition of the glass had changed; on placing one half of the divided glass on the other half, the fringes and black bands disappeared—on folding one half on to the other, the black bands presented the appearance that would have been produced by glass of double the thickness. These facts show, that the molecular forces on the glass were arranged symmetrically in reference to the line of parting: and we may conclude that toughened glass being in a state of tension, similar to that of the Rupert drop, may be divided or pierced, provided that the molecules of the pieces produced are able to rearrange themselves into a stable equilibrium. Polarized light shows the directions on which the division can be made with safety.

M. de Luynes, in his communication referred to above, gives an account of some experiments performed on plates of glass of the same quality, tempered by this process, and untempered; one or two examples will suffice. A tempered plate measuring about [1] 6½ inches by 5 inches, and 2/10 inch thick, was placed between two wooden frames, and a weight of over 3½ ounces (100 grammes [2]) was allowed to drop upon it from a height of more than 13 feet (4 mètres [3]) without breaking it. It only broke, when double the weight was employed from the same height. A piece of ordinary glass under the same conditions broke, with the weight of 3½ oz. dropped upon it from a height 16 inches (0·40 mètre). Plates of toughened glass were allowed to fall on the floor from a height, or were thrown to a distance, without breaking. A rectangular piece of ordinary window glass, about 1/10 inch in thickness, was bent into the form of a bridge, and then subjected to the tempering process; placed upon the ground; it bore the weight of a man easily without breaking. A commission, instituted by the French naval authorities, to inquire into this process of M. de la Bastie, has reported at some length on the subject. The following series of experiments were tried with a view of ascertaining the comparative power of resistance of tempered and ordinary glass. The plates experimented upon were placed loosely in wooden frames constructed for the purpose.

Rectangular plates about 21 inches (0·525 m.) *by 10 inches* (0·248 m.) *and 1/6 inch* (0·004 m.) *thick*.

The frame with the glass inserted was laid on the ground, and in the middle of the plate a weight of more than 10 lbs. (5 kilogrammes [4]) was placed, and upon it as a base, other weights were placed, care being taken to avoid all shock.

1º *Ordinary glass*, broke with a weight of about 70 lb. (35 kilos.) having resisted weights of from 30 to 50 lb.

2º *Toughened glass* resisted fracture until a weight of more than 510 lb. (255 kilos.) had been added, and then was not broken. The experiment was not carried to its limit for want of weights.

Rectangular plates, about 13 inches (0·325 m.) *by 10 inches* (0·248 m.) *and 1/5 inch* (0·005 m.) *thick*.

These plates were allowed to fall flat on to a floor of wood or thrown to a distance and allowed to fall.

1º *Ordinary glass* allowed to fall flat from a height of 1-2/10 inch (0·03 m.) was broken at the first trial.

2º *Toughened glass.* Thrown to a height 6 feet 6 inches (2 mètres) and to a distance of 13 feet (4 mètres) was also broken at the first trial. The piece, however, which had sustained the weight of 510 lb. did not break till the fourth trial.

Rectangular plates, about 10 inches (0·245 m.) *by 6 inches* (0·157 m.) *and ¼ inch* (0·007 m.) *thick*.

These plates were subjected to the same kind of tests as the foregoing. After raising them to a given height they were allowed to fall flat upon a wooden floor.

1º *Ordinary glass* raised to a height of 20 inches (0·50 m.) was broken on falling.

2º *Toughened glass* resisted successive falls of from 20 inches (0·50 m.), 32 inches (0·80 m.), 5 feet (1·50 m.), and 5 feet 7 inches (1·70 m.), but was broken when dropped from a height of 6 feet 6 inches (2·0 m.).

Rectangular plates about 10 inches (0·245 m.) *by 6 inches* (0·157 m.) *and 1/5 inch* (0·006 m.) *thick*.

Placed in the frames, they were held in position in the rabbets by laths nailed to the sides so as to prevent any play. The frames were raised to different heights and allowed to fall in such a manner as to cause as much vibration as possible.

1º *Ordinary glass* was broken with a fall of about 2 feet (0·60 m.).

2º *Toughened glass* resisted falls from heights of 3 feet 3 inches (1 mètre), 6 feet 6 inches (2 mètres), 8 feet (2·50 m.), 9 feet 9 inches (3 mètres), and 14 feet 6 inches (4·50 m.). It was only broken by a fall of 19 feet 6 inches (6 mètres).

Rectangular plates 6 inches (0·158 m.) *by 4¾ inches* (0·120 m.) *and 1/5 inch* (0·006 m.) *thick*.

These plates were placed in the frame on the ground, as has been previously explained. Known weights falling from known heights were made to strike the plates exactly in the centre. The weights consisted of bronze spheres, one weighing 3½ oz. (100 grammes) and another of twice that weight.

1st. *Ordinary glass* resisted the weight of 3½ oz., falling from heights of 8 inches (0·20 m.), 12 inches (0·30 m.), 16 inches (0·40 m.), but was broken by a fall of 20 inches (0·50 m.).

2nd. *Toughened glass* resisted the blow of the 3½ oz. weight falling from heights of 20 inches (0·50 m.), 40 inches (1 mètre), 60 inches (1·50 m.), and 6 feet 6 inches (2 mètres). The 7 oz. weight (200 grammes) being substituted, the plate was broken by it, falling from a height of 60 inches (1·50 m.).

Rectangular plates, 6 inches (0·158 m.) *by 4¾ inches* (0·120 m.) *and 1/6 inch* (0·004 m.) *thick*.

The same conditions were maintained as in the previous trial.

1st. *Ordinary glass.* The 3½ oz. weight was allowed to fall from heights of 1 foot (0·30), and 16 inches (0·40 m). It was broken by the second blow.

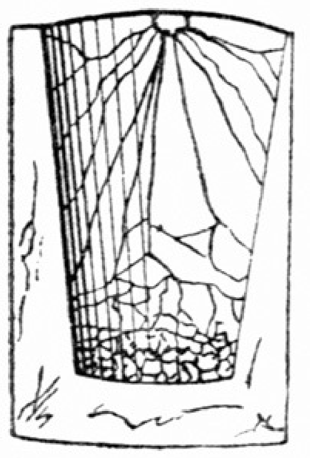
2nd. *Toughened glass.* This resisted the 7 oz. weight falling from heights of 2 feet 4 inches (0·70 m.), and 2 feet 8 inches (0·80 m.), but broke when the weight fell from 39 inches (1 mètre).

It appears then from these experiments, that toughened glass will resist a blow five times as great as ordinary glass, and will bear seven times as great a weight.

I have now detailed most of the useful experiments which have been made by competent observers upon toughened glass, as well as some which have been conducted in my own laboratory. The result of my own personal investigations I will now lay before the reader. I was consulted some time ago by a gentleman interested in the introduction of toughened glass into this country, as to whether this kind would become untoughened in time. I feel no hesitation in stating that when the process has been perfectly done, the glass will remain in the same state for any length of time, provided it be not treated in any way which is calculated to rupture the external hard bond that holds together the inner particles of the glass. I feel quite sure, that no fear of this kind need interfere with the benefits, whatever they may be, which are to be derived from submitting glass articles to the toughening process.

A tumbler which had been toughened in Monsieur de la Bastie's works, was, in my presence, thrown upon the ground, yet it did not break. It was a large soda water glass. I kept it for some time, and after considering the matter carefully, I felt, that if it were thrown down in such a way that the whole of its side, from base to rim, came in contact with the ground at once, and it then stood this test, it would prove that the whole of the glass was in the condition of the Rupert's Drops, and would therefore bear the concussion without fracture. I held the glass and let it fall, so that it actually reached the hard floor on its side. It immediately broke all to pieces. Now on the first occasion when this glass was thrown down, it was tossed somewhat upwards into the air, and the bottom being heavier reached the ground first, and it did not break. I have also seen in glass-houses, where the tempering process is carried on, tumblers thrown down in a similar manner, and I noticed, that whenever they fell upon their bottoms, they were uninjured, as also in cases where they fell upon their rims in such a manner, that the curve of the rim acted as an arch, as in the old trick of turning a wine-glass off the table so as not to break; but in other cases where the tumblers fell flat upon their sides, fracture followed. I carefully gathered together the pieces of the large tumbler which I broke myself in this manner, and examined them, and found that the solid bottom was broken in the same manner as the Prince Rupert's drops break, viz., into a large number of small pieces, having in all respects similar properties. The glass for an inch or two above the bottom broke into small pieces, but larger than those into which the bottom itself broke, and the upper portion of the tumbler was fractured just as an ordinary tumbler would be. On careful examination, microscopic and otherwise, the small pieces were found to have the character of Prince Rupert's, whereas the larger from the upper part of the glass had none of these characteristics in the slightest degree.

These observations led me to perform an experiment. A toughened tumbler was filled with plaster of Paris, which was allowed to set. Its outside was then encased in plaster of Paris, and when the whole was hardened, a pair of pincers were applied to a portion of the tumbler's rim, and with a violent wrench the tumbler was broken. A rather smart shock was communicated to the arm of the operator, very much resembling, as he said, the shock of an electrifying machine. On removing the plaster of Paris, it was found that the whole of the tumbler was fractured, and, as will be seen by the accompanying illustration, in a manner similar to that which has already been described.



From this and other similar experiments, I was led to the conclusion that none of the toughened articles which have cavities in them, have thoroughly undergone the toughening process.

Having been requested to attend a series of experiments performed by a glass manufacturer in London, which consisted in the manufacture of a number of toughened glass tumblers, I noticed certain facts which led me to form conclusions as to how it was that the tumblers, the fracture of which I already explained, break in this peculiar manner. I will first describe the way in which these tumblers were made and toughened. By the side of the glass blower there stood a metal vessel, about three feet six inches high, and, perhaps, from two to two feet six inches in diameter. This was filled with melted fat or oil of some kind at a temperature of about 80° Fahr. Inside this vessel, which was open at the top, there was a wire cage, with a trap door at the bottom about one foot in diameter, and of about the same depth. The glass blower, after finishing his tumbler on the pontil, held the pontil in a horizontal position over this metal vessel, struck it a smart tap, and the glass tumbled off into the wire cage. The glass was at a very high temperature. In almost every instance the glass fell into the melted fat, as a glass thrown in a similar manner will fall into water. It sank gradually bottom downwards, and the liquid guggled into it as it sank. Here, then, it is clear that every portion of the hot tumbler did not come in contact with the oil at the same moment, in fact there was an appreciable lapse of time before the tumbler disappeared beneath the surface of the liquid. Now there must be a limit as to the temperature of the article to be tempered and of the liquid by which it is to be tempered, that is to say, if at a certain temperature glass can be tempered by being plunged into the liquid of a certain temperature, if these temperatures are varied similar results will not follow. The upper portions of the glass coming in contact with the tempering liquid at a lower temperature, as they must have done, were not properly tempered, and this I have clearly proved by the facts I have already stated. From these remarks it seems tolerably clear that, until some method is devised of bringing all the parts of the heated glass in contact with the cooling liquid simultaneously, the tempering of the article cannot be perfect throughout its whole surface. As I desire, and very sincerely, that these processes should be brought to perfection so as to render them useful, I willingly give this result of somewhat lengthened investigations to those whom it may commercially concern, and I hope that they will find, on investigating the matter, that my observations have been tolerably correct, and that they will be able to devise a method which will remedy in many cases manifest imperfections of their present system. All the accidents which have happened to tempered glass, which have been recorded in the newspapers, can be accounted for on the principle which I have just endeavoured to explain, for there must be instability, where the bonding material of the internal particles of the glass is in different states of hardness; so that there is no difficulty in conceiving how a gas globe could break apparently spontaneously, for a portion of it which was not fairly toughened might be exposed to a somewhat sudden rise of temperature, produced, it may be, from a draught blowing the flame upon that particular spot. Articles such as saucers, made of glass, which, being flat, or nearly so, can be plunged into the tempering liquid with great rapidity, are usually tempered all over, and these, when toughened, can be thrown about and allowed to fall on hard floors with impunity, thus proving the facts which I have endeavoured to establish. I hope to be able to continue my investigations, and should they be worth anything, will give the results of them to the public. Before quitting this subject, I shall make a few remarks upon the process for toughening glass, which is said to have been purchased by the Prussian Government.

This process is described as consisting in the application of superheated steam to the glass, brought up to a temperature near to its melting point. Having facilities for making experiments of this kind, I have had them tried with great care, but in no case have I met with a satisfactory result. This probably is owing to the fact, that I did not comply strictly with the condition of the experiments performed by the German chemist who is said to have made the invention, nor do I see from analogy how this process is likely to effect a change in the glass similar to that arising from M. de la Bastie's dipping process.

If glass, instead of being taken from the annealing kiln at the proper time, be left exposed in the hot part of it, at a temperature just below that at which it softens, it will be found to become gradually opaque on its surface. Some experiments were performed many years ago by Réaumur, who exposed pieces of glass, packed in plaster of Paris, to a red heat, which became gradually opaque, and lost altogether the character of glass, the texture of their material becoming crystalline, and also effected by sudden changes of temperature. Glass treated in this way was called Réaumur's porcelain. All glasses do not undergo this change with equal rapidity, and some do not experience it at all; but the commoner kinds, such as bottle glass, are the best to experiment upon, for the more alumina that it contains—and it is known that bottle glass contains a considerable quantity—the more readily does it undergo this change, which is called *devitrification*. In what it consists, is not at present well understood, but it offers a field for investigation, which may produce results of very considerable benefit to manufacturers of glass.

Soluble Silicates.—An article on glass in a modern scientific work like the present would not be complete without a notice of the manufacture of soluble glass and the uses to which it has been and may be applied. It has already been mentioned that when silica or sand is fused with an excess of alkali, the resulting glass is soluble in water.

Soluble glass is made on a large scale in three different ways. First of all, if flints, that is, black flints, which are found in chalk, be heated to a white heat, they lose their black colour and their hardness, and are easily crushed to small pieces; and if flint in this condition be placed in a wire cage and put into a jacketed iron digester, that is, an iron digester which has an inner and an outer skin, with a free space between the two, so that steam may be forced into it from a boiler under pressure; and if the digester be screwed down tightly with an iron cover, and steam then be allowed to pass into the space between the two, the temperature can be raised at pleasure, according to the pressure under which the steam is introduced. If the valve of the boiler be loaded with a 60-lb. weight, the temperature of the water warmed by the steam will rise considerably higher than that of ordinary boiling water; and if this water be saturated with caustic soda, it will dissolve the flints slowly, forming silicate of soda, that is to say, the silicic acid of the flint will unite directly with the soda of the solution, and silicate of soda will thus be obtained. For certain applications, the silicate so formed is not sufficiently pure, because the soda used often contains a certain amount of sulphate, which will remain with it in the solution of silicate that is drawn off from the digester. This sulphate is very objectionable for certain applications of silicates, because it crystallizes out, and so destroys the substance, which the silicate is intended to preserve.

Another and a much better method is to heat together the silica in the form of sand with alkali, either potash or soda, in a reverberatory furnace, and as the glass becomes formed, to rake it out into water, and then gradually to dissolve it by boiling in suitable vessels. Here the sulphate, if it existed in the alkali, is decomposed by the silicic acid, and the sulphuric acid passes off through the flues of the reverberatory furnace.

There is also a very ingenious way of making silicate of soda, discovered by Mr. Gossage, and performed as follows: common salt is heated to a high temperature and volatilized, and in this condition is brought into contact with steam also at a high temperature, when a double decomposition takes place. Steam is composed of oxygen and hydrogen; common salt, of sodium and chlorine. The chlorine of the common salt unites with the hydrogen of the steam, and the oxygen of the steam with the sodium, so that hydrochloric acid and oxide of sodium are formed. Now, if these two substances at this high temperature were allowed to cool together, the action would be reversed, and the re-formation of steam and chloride of sodium would be the result; but in the strong chamber lined with fire-clay, in which these vapours are brought into contact, silica is placed in the form of sand made up into masses, and when the oxide of sodium is formed, it unites with the sand to make silicate of soda, and thus is removed from the action of the hydrochloric acid, not entirely, but sufficiently to produce a large yield of silicate of soda.

The properties of silicate of soda, as applied to the arts, are somewhat different from those of silicate of potash, so that one cannot always be substituted for the other. Both these substances are, when in solution and concentrated, thick and viscid, and have the property of causing paper, wood, &c., to adhere when applied as a gum or glue, and hence have been called "mineral glue." In a dilute state they can be used for coating stone, brick, or cement, and have the power of rendering them for a time waterproof, or nearly so, and of preventing the action of atmospheric influences, which too often produce the decay of some of the softer stones used for building as well as for cement. It has already been stated, that when carbonic acid is passed through a solution of silicate of soda, silica will be precipitated. Now, inasmuch as there is carbonic acid in atmospheric air, when these solutions are applied to the surfaces of a building, they will be acted upon slowly by the acid, and silica will be precipitated in the pores of the material to which the silicates are applied. But this operation is extremely slow, and, before it can be thoroughly completed, the silicates, being soluble, will get in part dissolved out by rain and moisture, and it is therefore advisable to use with them some material which will, by a double decomposition, form a silicate insoluble in water. The silicate, however, which is formed, should have cohesion amongst its particles, so that it will not only adhere to the stone itself, but its own particles will adhere to one another when it gets dry. Various methods have been tried to cause this insoluble substance to be formed upon the surface of stones, so as to fill up its pores and to make a protecting cover for it; but most of them have signally failed, because the new silicate produced by double decomposition has not had the necessary coherence amongst its particles. If a solution of chloride of calcium be added to one of silicate of soda, a silicate of calcium will be precipitated, and it was therefore thought, that by applying to a stone successive washes of silicate of soda and chloride of calcium, an insoluble silicate of calcium would be produced in the pores and on its surface. It is true that such a silicate is precipitated, and that, if the silicate employed be in excess of the chloride of calcium, the particles will be glued together by the adhesive powers of this silicate when it dries; but then the action of moisture upon it is to cause it to run down the surface of the building, and set free the particles of silicate of calcium which it held in combination. Other processes of the same kind have been tried, and with similar results; one great difficulty in the way of the success of this method of applying silicates being that, from the peculiar colloidal or gluey nature of the silicate, it does not penetrate to any considerable depth into the stone, and, if laid on first, prevents the penetration, as far even as it has itself gone, of the solution of chloride of calcium. If the chloride of calcium be used before the silicate, it will penetrate farther than the solution of silicate is able to reach, so that it is impossible to obtain, even supposing the substance to be used in equivalent proportions, a complete decomposition of the one by the other.

The great object to be attained in the preservation of stone by any silicious process, is to use *one* solution possessing the substances which, when the water has evaporated, will form a perfectly coherent mass for the protection of the stone surface. The depth of penetration, if it is sufficient to protect the outside of the stone from the disintegrating action of the atmosphere, need not be carried much more than one-sixteenth of an inch below the surface, for when old stones which have long been in positions in buildings, and which have not decayed at all, are examined, it will be found that they are covered with an extremely thin film of a hard substance, not thicker than a sheet of writing paper, which has for ages protected and preserved them from decay. This film is produced by a determination from the inside to the outside of the stone of a silicious water, which existed in it in the quarry, and which, when the stone was placed in the building, gradually came to the surface, the water evaporating and leaving behind it a thin film of silica, or of a nitrate—most likely the latter.

If alumina be fused with potash, aluminate of potash, soluble in water, is made; if, however the solution is too concentrated, a certain quantity of the alumina will be precipitated; but if it be dilute, the whole of the alumina will remain in solution. When aluminate of potash of specific gravity 1·12 is mixed with a solution of silicate of potash of specific gravity 1·2, no precipitate or gelatinization will take place for some hours; the more dilute the solution, the longer will it remain without gelatinization, and of course the thinner it will be, and the greater power of penetration it will have when applied to a porous surface. When solutions of aluminate of potash and of silicate of potash of greater density are mixed together, a jelly-like substance is almost immediately formed, and sometimes even the whole mass gelatinizes. If this jelly be allowed to dry slowly, it will contract, and at last a substance will be left behind sufficiently hard to mark glass, though the time for this hardening may be from one to two years; and on examination it is found that this substance has very nearly the same chemical composition as felspar, and is perfectly insoluble in ordinary mineral acids. Now, suppose a dilute solution of this mixture to be applied to the surface of stone, the silicate and aluminate of potash will gradually harden and fill up the interstices of the stone; and as both the substances entering into combination are contained in the same solution, they will both penetrate to the same depth. Inasmuch as the artificial felspar is not acted upon by destructive agents which would disintegrate the stone, it becomes a bonding material for its loosened particles, and at the same time gives a case-hardening to the stone, which no doubt will as effectually protect it against atmospheric influences as in the case of the hardening of the natural one. We have a tolerable guarantee that this will be so, if we consider the number of enduring minerals into the composition of which silica, alumina, and potash enter, and also of the almost imperishable character of granite, which is so largely composed of felspar. Many experiments have been performed on an exhaustive scale with these materials, and in every case it has been found that they have answered the expectation of those who have thus tested them. It is, however, necessary to state, that in making these experiments, great care must be used to employ the mixed substance in solution before gelatinization has set in, for if this has occurred, even to the slightest extent, a surface coating is formed on the stone, which, not having formed a bond with it, easily rubs off.

Another application of soluble silicates in this or other forms is to render walls of buildings which are porous, waterproof. A colourless, transparent material which can effect this object is doubtless desirable, as anything like an opaque wash, if applied to brick-work, would destroy the colour of the bricks, and therefore the character of the building constructed with them. The silico-aluminate of potash may be used for this purpose, as above directed; and even silicate of potash alone, provided it be in sufficient quantities, will answer well, if from year to year, for two or three years, the application be renewed, so as to fill in spaces, wherever the silicate may have been in part dissolved out. When the silicate of potash alone is used, the action of the carbonic acid of the air in precipitating the silica is depended on, and while this action is going on, portions of the silicate not acted on will be dissolved out.

Many years ago, an effort was made in Germany to revive the ancient art of fresco painting, and with very considerable success. It was found, however, that our climate is not suited to the permanence of this method of decoration, nor indeed is any climate absolutely suitable, because in fresco painting, the surface only of the lime is coloured with pigments laid on, so that any influence which would destroy the lime surface would cause the removal of the pigments; and from the porous nature of the surface of the work after it is completed, absorption of moisture will from time to time take place, causing the adhesion of dirt and other foreign substances which may fall upon it, and which it is almost impossible to remove without detriment to the picture. Dr. Fuchs, of Munich, discovered a method of painting with soluble silicates, which has been tried with considerable success in Berlin by the late Professor Kaulbach. On a properly prepared ground, the painting was executed in colours mixed with water, which, when dry and the painting finished, were fixed to the wall by the application of soluble silicates. For the preservation of the work, Dr. Fuchs mainly relied upon the action of atmospheric carbonic acid. Now, when carbonic acid acts upon silicate of soda or silicate of potash, we have already seen that the silicic acid is precipitated in the hydrated form, and that the carbonic acid has united with the soda or potash to form carbonate of soda or carbonate of potash. These substances being left in the painting and penetrating to a certain depth beneath its surface, must find their way out, and in almost every instance have done so in the form of an efflorescent substance, which has caused the picture to have the appearance of being mildewed over its surface. Sometimes, however, sulphates occur in the ground, and then sulphates of soda and of potash have been formed, injurious to the permanence of the surface of the picture, because they crystallize and force off portions of the lime and sand of which the surface is composed. The effect of the efflorescence of the carbonates on the surface of a silicious painting may be seen in the famous picture of the meeting of Wellington and Blucher, in the House of Lords, painted by the late Mr. Maclise, R.A. When, however, the solution of aluminate and silicate of potash is used with the pigments on a properly prepared ground, there is no fear of this efflorescence taking place, and paintings executed with it have stood for many years, without giving any signs whatever of decay.

To those interested in this subject, it is desirable that they should perform a series of experiments themselves, and ascertain the best methods of practically applying this vehicle in the execution of large mural paintings. They will find that, although at first they may meet with some difficulties, yet after a while these difficulties will vanish, and they will have a material to work with, which will meet all their requirements.

In an article so brief as the present, it is impossible to enter fully into all the details of the manipulation of this particular process of painting; it is, however, most desirable to give a short account of the method of preparing the ground and of applying the colours, leaving the rest to be learned from practical experience.

Angular fresh-water river sand, well washed, should be mixed with sufficient lime to cause it to adhere to the wall on which it is placed, and this in all cases should be freshly plastered in the ordinary way. No plaster of Paris (which is sulphate of lime) should be used in the preparation of the groundwork. The coating of fine sand and lime is laid on to a depth of about an eighth of an inch, and when dry, an application of dilute silicate of potash should be made, in order to bond together the particles of sand which, owing to the employment of so small a quantity of lime, can be readily brushed off. As soon as these particles are well fixed together and do not come off when the hand is passed over the surface of the wall, the ground is in a fit state for the commencement of the painting. The colour should be used with zinc white, and not with lead white, and, of course, they must be in the state of fine powder, and not ground up with oil or any such material. The artist can use his mixture of silicate of alumina and aluminate of potash of the strength already described; he may, when desirable, dilute it to a certain extent with water, but he should not do so too much. He can then paint with it just as he would with water in water-colour painting; and if he finds that any portion of his colours, after they are dry, are not sufficiently fixed upon the wall, he can then with a brush pass over them a coating of the clear liquid, used a little stronger. When the whole work is finished, it will perhaps be desirable to give it one or two coats of a very dilute solution of silicate of alumina and aluminate of potash. After a time, owing to the contraction in drying of this material, it would be advisable—say, after the lapse of two or three months—to again apply a coat of it somewhat stronger; and again, if after a year, or more than a year, it should appear that any portions of the surface were becoming loose, another application of the mixed silicate of alumina and aluminate of potash to these loosened parts alone will be desirable. This repetition may appear to some to be an objection to the process, but it is not so, however; for in the formation of those natural substances, such as flints, which we find so hard, no doubt a very great lapse of time occurred in the induration of the gelatinous silica which formed them. Neither do we object from time to time, at intervals of years to renew the coats of varnish on oil paintings, in order to preserve them or to bring out afresh the brilliancy of their colours.

The soluble silicates are frequently used as bonding materials in the manufacture of artificial stone and cement, very good results having been attained. The objection, however, to their employment for these purposes is the expense of the material of which they form a constituent part, and it seems almost impossible ever to bring it into competition with dressed natural stone. But for ornamental purposes, from the plastic nature of the substance when in the wet state, it can be pressed into moulds, and wherever plaster mouldings are admissible, no doubt this material would be useful for certain kinds of ornamentation. Some years ago, Mr. Ransome, of Ipswich, after having made his artificial stone with sand and silicate of soda, heated it in ovens, so as to produce a hard and semi-vitrified mass. A church, the mouldings of which are made of this stone, may be seen at the bottom of Pentonville Hill, London; and certainly as to durability, there is no doubt that the substance has answered very well. But from difficulties in manipulation and other reasons, that gentleman gave up this method of making artificial stone, and is now working another process which yields far better results. Silicate of soda is mixed with sand (generally Aylesford sand), and after the mixture is moulded and dried, it is exposed to the action *in vacuo* of chloride of calcium in solution. Whether the whole mass is placed in a vacuum chamber and then charged with chloride of calcium; or whether a vacuum is formed on the under side of the substance, and the chloride of calcium solution caused by suction to filter through it, is uncertain. However, whatever be the manipulative processes, the result is the same, and appears to be extremely satisfactory.

Soluble silicates produce very remarkable results when mixed with certain substances. If silicate of soda or potash be mixed with white lead, in a very short time it sets into a hard substance, just as does plaster of Paris when mixed with water. If powdered pumice-stone or sand, in the proportion of eight parts to one of carbonate of lead, be mixed together with soluble silicate, a very hard and coherent mass is obtained, and there seems no reason why a mixture of this kind, in which pumice-stone is used, should not be employed for the purpose to which pumice-stone is usually applied. It would have the advantage of being easily moulded into forms, so as to suit mouldings, which might by it be much more accurately and expeditiously smoothed down (as in the case especially of picture-frame mouldings), than they can be by the ordinary pumice-stone.

Another very important application of soluble silicates is the rendering of wood incombustible. Many experiments have been performed which show that when wood is thoroughly impregnated to a depth of a quarter of an inch or more with silicate of soda, it will not flame, but will only char. Now, supposing that the constructive timbers of a house were worked, and then placed in suitable vessels and saturated with silicate of soda, they would then be rendered practically fireproof, or at least it would take a very prolonged exposure to heat to cause them to smoulder away, while at no period of this time would they burst into flame. From the peculiarly gluey nature of these soluble silicates, they do not penetrate readily into porous substances; it has therefore been suggested that the impregnation of the wood should take place in vacuum chambers, just in the manner that the creosoting process for preserving railway sleepers is at present performed. It is most certainly advisable that the wood should be worked before being exposed to the silicating process, for that would render it so hard, that it would considerably increase the cost of labour in cutting and planing it.

At the commencement of this article, it was stated that silicic acid, or silica, could be made soluble in water. Some very interesting experiments were performed by the late Dr. Graham, Master of the Mint, which gave rise to the discovery of the process of dialysis. If some silicate of soda be mixed with water, so that not more than 5 per cent. of silica be in the solution (rather less is better), and if some hydrochloric acid be then added in sufficient quantity to make the liquid distinctly acid, and the mixture be placed in a dialyzing apparatus, the chloride of sodium formed by the union of the chlorine of the hydrochloric acid with the sodium of the silicate of soda will pass out through this dialyzing membrane, leaving hydrated silica behind, which will remain in solution in the water with which the silicate was mixed. The dialyzing apparatus is constructed in the following manner; a sort of tambourine ring is made with gutta percha, in place of wood, from 8 to 10 inches or even more in diameter, the depth, being about 2 inches. Another ring of gutta percha, of about an inch deep or even less, is made so as to fit tightly outside the tambourine; a piece of vegetable parchment is then moistened and placed over the tambourine, and the thinner ring is pressed over it, so as to secure it tightly. This is the dialyzing vessel, and it is into this that the mixture of silicate and hydrochloric acid must be put. The solution should not be more than an inch deep in the dialyzing vessel, which is then made to float upon distilled water in a larger vessel of suitable size. The distilled water should be changed every day, until no precipitate can be obtained in it with nitrate of silver, and when this point is arrived at, all the chloride of sodium will have passed through the vegetable parchment into the larger vessel of water, and nothing but silicic hydrate will remain behind in solution. If this liquid be allowed to stand for some time, it will gelatinize, and later on the jelly will contract, becoming extremely hard, so that lumps of it, when broken, will in their fracture resemble that of flint. No doubt, at some future period, some one will discover a method of rendering this condition of silica useful in the arts.

Soluble silicates are very useful as detergents. A small quantity of silicate of soda mixed with hard water renders it valuable for washing purposes. Silicate of soda is also used in the manufacture of the cheaper kinds of soap. We can hardly speak of it as an adulteration, because it renders the soap with which it is combined much more powerful in its cleansing action. I suggest to those interested in the application of science to the arts, that this subject will no doubt well repay experimental investigations.

It is much to be wished that those engaged in this branch of art and manufacture, and who have some knowledge of chemistry, would turn their attention to getting a better and more perfect method of making coloured pot-metal glass. I have been engaged for some time, and still am engaged, in experiments to effect this object. But inasmuch as my engagements are very numerous, and I cannot give the proper time to it I desire, I therefore take the liberty of suggesting to others the ways in which I am working, that they may be able to arrive at good results more speedily probably than I shall be able to do. If sulphate of copper be mixed with silicate of potash, silicate of copper will be precipitated. Now, if this be carefully washed and dried, it will be a silicate of a definite composition, and I propose to use such silicates as these with ordinary glass mixtures, in order to impart the particular colour which the oxide employed has been already described as giving to the glass. Silicate of manganese is prepared in a similar way to the silicate of copper; silicate of cobalt, and other silicates, can be used as staining materials for colouring glass. These mixed in due proportion would give tints, and would, I do not feel the slightest doubt, produce colours with much greater certainty than they are now produced, and tints hitherto unknown could be made to the great benefit of the glass-painter.

FURNITURE AND WOODWORK.

By J. H. Pollen, M.A., South Kensington Museum.

I propose in the following pages to give some account of the materials used in making furniture, and of the arts applied to its decoration. From the earliest ages of society, when men moved about in tribes, they had in their tents of camels' hair simple necessaries, such as their wants required. Before people were gathered into distinct nations, or cities built with walls and gates, there were still certain human wants that must needs be supplied; and the objects that were needed to enable mankind to live with convenience and decency were found in their furniture. To this very day we may see Arab tribes wandering over sunny deserts, seeking pasturage, sowing here and there an acre of wheat or barley, or gathering dates. Their camels and dromedaries are their waggons, their horses are their friends, their families and those of others that make up their tribe are their only nationality. Yet they furnish in some sort the temporary homes which they shift from one spring of water to another, as the patches of grass or grain grow up and ripen. Their chief wants are, a cloth strained over three staves to make a house, mats or carpets to lie on, a few bowls to cook in, saddles of wood, and a few baskets or chests, made of light sticks fastened together.

In later periods of history and in more conventional states of society, we shall find this primitive type of furnishing carried out with growing splendour. In the West and in the East, in ancient and mediæval times, great rulers, though constantly in the saddle, have been followed by enormous trains of camp followers, by whom costly furniture, hangings, vessels of plate, and other luxuries, have been carried for the convenience of the leaders and warriors of moving hosts; and of course this splendour was the measure of the state and magnificence kept at home. The wealth or feudal state, shown in the furniture of old castles and palaces, extended not only to halls and rooms, but to dresses, and armour, weapons, the furniture of horses, tents, and other objects that could be carried on distant expeditions.

Ancient nations have been as well, and more splendidly, if less conveniently, provided with furniture for their houses than modern ones. It happens that there are distinct records of many kinds, showing what wealth and elaborate decoration some of the oldest races, such as the Assyrians, the Egyptians, the Persians, and the Greeks, bestowed on their thrones, beds, chairs, and chariots. Beds of silver and gold are mentioned in Esther i., and the curtains of the bed of Holofernes were covered with a canopy of purple and gold, with emeralds and precious stones (Judith x. 19; Esther i.). Modern princes in India continue to devote their jewels and gold to similar uses. It must be borne in mind also, that this kind of splendour is an investment of property in times and countries in which banks, insurance offices, government funds, and other organized means of investing money are unknown.

Silver, if not gold, has been used occasionally, not only in the East, but in Europe, for seats, tables, even the frames of pictures and mirrors. The royal apartments in Whitehall were completely mounted with hammered and filagree silver furniture in the seventeenth century. Carlyle records of Frederick the Great, that silver ornaments were kept in his palace, and turned to account under the exigencies of war. But of furniture generally, wood is the readiest and most proper material. It is handy, easily worked, light to carry about, and may be manufactured with or without decorations of carved work, or of any other kind. Hence, in giving an account, whether historical or mechanical, of furniture, I class it under the more general head of woodwork. Any other materials, either for the framing or ornamentation of furniture, are exceptional. The remarks now to be submitted to the reader will refer to wood that is manufactured, though I shall not enter on the interesting subject of wood structure, which has been applied to such noble and elaborate uses, and of which such splendid monuments of many periods still remain for us to study.

Most of the methods used for decorating woodwork made up into furniture are still in regular use, and the processes of putting it together are the same as they have always been. The reader may satisfy himself on this point any day by a walk in the Egyptian rooms and in the Nineveh galleries of the British Museum. In both these sections of that wonderful collection, there are remains of woodwork and of furniture, made of wood three or four thousand years old, such as stools, chairs, tables, head-rests or pillows, workmen's benches of Egyptian manufacture, fragments less complete of Nineveh make that have been portions of various utensils, and precious articles of sculptured and inlaid ivory that have been inserted into thrones and chariots. These pieces of furniture have been mortised together, or joined by dowels, dovetailed at the angles, glued, nailed, or, in short, made up by the use of several of these methods of junction at the same time. And no great changes have been introduced in the various ways of ornamenting furniture. The Egyptian woodwork was painted in tempera, and carefully varnished with resinous gums. It was inlaid with ebony and other woods, carved, gilt and, perhaps, sparingly decorated with metal ornaments. The Greeks inlaid chests and tables with carved ivory and gold, sometimes relieved with colour. The Romans, who made much furniture of bronze, cast, inlaid, damascened and gilt, made much more in wood, which they stained, polished, carved, and inlaid. Mediæval furniture was put together with mortises, tenons and glue, and was gilt and painted; the painting and gilding being laid on a ground prepared with the utmost care, and tooled and ornamented in the same way that bookbinders ornament leather. At a later period, a beautiful manufacture was carried on in various parts of Italy; a sort of mosaic in very hard stone, such as agate, lapis lazuli, and other precious materials. The Italians also used these beautiful stones inlaid in ebony. But the furniture most valued in modern times has been that which owes its name to Boulle, a French artist of the seventeenth century; and the marquetry, or wood mosaic surface decoration, which reached so high a standard of excellence during the last thirty years of the eighteenth century in France.

The former of these two classes of manufacture made, if not originated, by Boulle (and I am inclined to think that he was not the first maker), was a marquetry, or surface decoration, not composed of various woods, but of tortoiseshell and brass, with the occasional introduction of other metal, and with metal enamelled in blue and other colours. The materials principally in use, however, in Boulle marquetry are tortoiseshell and brass. In the older work, viz. that of the seventeenth century, the tortoiseshell is dark, and left in its natural hue. In later Boulle, called new Boulle, the tortoiseshell is reddened by colour, or by gilding laid under it. There is much grace and variety in the delicate arabesque designs in which one material is inlaid in the other. Parts of the surfaces are sometimes diapered, as a contrast to the free lines and curves of other parts. The inlaid surface of Boulle work is framed in by borders, cornices, or handles of brass or gilt bronze, giving a massive architectural character to the whole.

Thus if we look back to the history of furniture, not only will every kind of splendid material be found devoted to the manufacture or decoration of it, but the best art too of many different periods that money could command. It is in the late times of antiquity, and since the period of the Renaissance in modern times, that works of art have been kept on shelves or gathered into galleries. Many works of great masters, such as the chest of Cypselus, and the chairs of the great statues of ivory and gold, were prepared for celebrated shrines and temples in the cities of Greece. It was but the excessive wealth of great patricians in Rome and Constantinople that led to their becoming collectors, whether of sculpture, painting, or sumptuous silver plate. The chief object of rich and accomplished men in most ages of luxury and refinement has been, to make the house, its walls, ceilings, floors, and necessary or useful furniture, costly and beautiful. It was the same in the days of Donatello, Raphael, Cellini, and Holbein. Chests and trays were painted, together with gems, dies, brooches; table plate was modelled and chiselled; while chairs of wrought steel, or tables, cabinets, and other pieces of rich furniture, were either designed or carried into execution by these masters with their pupils and followers. In some instances, as, e.g., in that of the famous Pomeranian cabinet, in the Kunst Kammer in Berlin, a long list has been preserved of artists and craftsmen of note in their day, who combined to produce monumental examples of actual room furniture.

It cannot be denied that though great pains are taken and much expense is incurred in modern furnishing, the habits of the day lead rather to the search for comfort than for grace or beauty; and convenience rather than intrinsic value or artistic excellence. Nevertheless, a certain amount of decency and splendour is indispensable in both receiving and sleeping rooms; and though a house really well, that is beautifully, furnished is of rare occurrence, this is not for want of serious efforts, nor altogether to be laid to the account of unwillingness to spend money for such a purpose. Whether the "art of furnishing" or the desire to have what people require for use in their houses more becoming and beautiful, be a rising influence or not, it is certain that the "fancy" or ornamental furniture trade is of large and increasing importance, corresponding to the increased size and cost of modern London and country houses, compared with those built during the reigns of William III. and George IV. Every tradesman who has the pretension to repair chimney-pots, to whitewash, or paint house-fronts, ceilings, or offices, writes up the word "decorator," on his shop-front.

The Qualities required in Furniture.

We may consider furniture under two broad divisions, that which is made to be handled and moved about, and that which is for use but not meant to be handled or moved. We may add a third division in the actual fixtures of the house, made by the joiner and meant to be ornamental fittings or completions to the builder's and carpenter's work.

Under the first head will be included light tables, chairs, couches, and other movable objects; under the second, cabinets, book-shelves, frames, mirrors, and so on; under the third head come flooring, panelling, window shutters, door-frames, stair-rails, &c.

1. Chairs, Tables, etc.

The essential points in a well-made chair are comfort, lightness, and strength. Of course, as men and women are pretty much of the same proportion all over the world, chairs, of which the seat is about the height of the lower process of the human knee-joints, must be of the same height, or but slightly varied, in every country. From the habit that so many persons have of throwing their whole weight back and, as we are told, in some countries, of balancing their persons on the back legs of their chairs and inclining their legs in the direction of the chimneypiece, there is often an immense strain on the back joints of chairs. Whether we lean back or swing on them, the junction of the seats of chairs with the backs is always subject to severe trials; and on no article of furniture in common use is such good joinery required. It is worth while to look at the old wall paintings of the Egyptians, as they are given in Rossellini and the great French book of the 'Description de l'Egypte,' to see what capital workmanship those most ancient carpenters bestowed on their chairs. Those of the best and oldest periods are without connecting bars to the legs before or behind, all the strength of the construction being centred in the excellence of the joints of the seat with the back and legs; and in modern workshops, the highest skill is applied to ensure strength in these points of junction. If the wood is thoroughly dry, the mortises and tenons fitting perfectly, and the glue good, the different parts are so wedded together that the whole structure becomes one piece, as if nature had made a vegetable growth in that fashion, all the fibres of which have continuous and perfect contact with each other. If, however, there is a deficiency in any of these conditions, these joints fail. If the wood shrinks, or the tenons do not fit the mortises all through, or the glue is deficient, these various portions speedily come to pieces. Sofas, couches, and stuffed chairs are so much more massive in construction that there need be no risk of such a kind of disintegration.

The members of which a chair is made up may be either turned in the lathe, or left massive enough to allow of carving on the legs, backs, or round the framework of the seat. Turned work can be lightly inlaid with ivory, as that of ancient Egypt, painted, gilt, or mounted (lightly also) with metal.

The subjects of the carving may be either figures of men, horses, lions, or the heads and legs of such animals, acanthus leaves, and arabesques. Many of these ornaments have been used from ancient times, and revived at various historical periods. For modern rooms the lightest construction is most in place, and therefore carving should be compact in composition and delicate in execution, without prominences or undercutting that would interfere with comfort or be liable to breakage.

A certain architectural character is given to chairs by cutting flutings down the legs, or by borrowing other slight details from architecture. The upholstery of chairs will always be their most noticeable decoration, and this applies still more to lounging chairs and couches of all shapes and sizes, as the framework of them is so much less observable in proportion to their upholstered surfaces.

Tables, lampstands, &c., being generally, though not always, meant to be moved about, require as light a construction as is consistent with strength. The surface of all but small tables is beyond the dimensions of a single plank of wood. The outer and inner portions of a log or plank are of different fineness of grain, contain varying proportions of sap, and shrink in different degrees. Single planks of wood, therefore, can only be exceptionally used for table tops. Generally, they are made up of portions of planks selected with great care, grooved on the edges, with a tongue or slice of wood cut the cross way of the grain, uniting the planks about the middle of their thickness; the edges are then firmly glued together. If the surface is to be of wood which can be procured in large pieces of straight or continuous grain, such as mahogany, the wood is solid throughout; if of some rare wood or rare figured graining, such as the roots or wens of oak, this ornamental surface is laid on in thin slices with glue and heavy pressure. This is known as *veneering*. The surface is sometimes inlaid with ivory, metal, mother-of-pearl, slices of agate and other substances, as in the Boulle or marquetry work already alluded to.

The frame of the table is either a deep rail not far within the edge, or a thick pillar or leg or several legs collected, mortised into a broad expanding foot and supporting a spreading framework above, to which the top itself can be fastened, and stretching far enough all round in the direction of the edges to give a firm support.

The decoration of the top can only be superficial if the table is for use, and any decoration by carving, piercing, and so on, must be confined to the framework and the supports. These parts can be, and have been at all times decorated as the framework of chairs, and by very much the same kinds of ornament.

To tables of more modern periods, little galleries of pierced work or of tiny balustrades are sometimes added. They belong to the age of porcelain collectors, hoops, broad coat-skirts, and tea-parties, and are intended to save delicate wares from being swept to the ground. Side tables, and such as are made to support heavy objects, can be treated with more massive frame work and supports, and the carving and decorations will be bolder and larger accordingly.

2. Cabinets, etc.

I will proceed to the second division of furniture, cabinets, bookcases, and other standing objects, which are more or less immovable. But shelves and china trays must be placed in secure parts of the room, if they are not actually fastened to the wall. The former must be strong to support the great weights laid upon them, and the supports or framework, which is all that would be seen, may be carved or decorated with surface or applied metal ornament. On a large scale, fittings of this kind belong rather to architectural woodwork. China holders, whether placed on the ground or fixed against a wall, are properly treated with shelves quaintly shaped on plain and light, pierced galleries or gilt decorations corresponding with the apparent lightness of pieces of porcelain. The wood and lac work cabinets of the Chinese; and the complicated, but not ungraceful, gilt mirror frames and flourishing acanthus work of the Italians, French, and Germans, of the last century, seem specially suited for showing off this gay and fragile material. The collector proper will probably place his treasures under glass, and with little regard to the framework of his cases. Here china and china stands are treated only as decorations.

As to cabinets, they are the most precious, if not the most useful of all pieces of furniture. They have generally been intended to hold family treasures, are not required to be moved, and have therefore been the richest and most decorated objects in the room. Cabinets are the legitimate descendants of the chests of former days containing bridal outfits and trinkets, or plate, jewellery, and other valuables. They were carried from town to country, from grange to castle. About the beginning of the sixteenth century, the personal habits of great men became less nomad, and their chests were no longer liable to be packed and moved away. These receptacles were mounted on stands at which height the lids could not be lifted, and doors were substituted. Drawers took the place of shelves or compartments, and every sort of ingenuity was applied to make these pieces of furniture quaint and splendid inside and out.

As to shape, it is contrary to their purpose of convenience and interior capacity, to make cabinets, cupboards, or other receptacles, with showy and spreading architectural details, such as cornices, architraves, columns, pediments, and the like. All these parts, which are laborious and costly in construction, are so many additions to its size, and make no more room inside to compensate for this expenditure. Cabinets should, in propriety, be as big and convenient inside as their size would lead us to expect.

On the other hand, the many fine examples made in the sixteenth and seventeenth centuries in this country, Holland, Germany, France or elsewhere, have been generally intended for rooms larger, higher, and with fewer pieces of furniture in them than those of our modern houses, not to speak of the massiveness of fireplaces and fittings with which they were in character. It is their age, and the connection, which we cannot help tracing, with old houses and bygone generations which give architectural cabinets an interest now.

In construction, the skill of the cabinet maker will be shown in the neat and convenient arrangement of drawers of various depths and sizes, shelves or repositories, so contrived as to turn the entire internal space to account. The most curious contrivances are often found in old German, English, and French cabinets, bureaux, secrétaires, and other varieties of this kind of furniture. Pediments, capitals of columns, and other parts of architectural fronts are made to open, and secret drawers stowed away with an ingenuity almost humorous. It is upon the fronts and stands that the skill of great masters of the craft has been bestowed. The large wardrobes, or "armoires," of Boulle are examples of great inventive and designing power, as well as the marquetry of Riesener and David, and the chiselled metal-work of Berain, Gouthière, and that of many English artists.

As in past times, and so in our own, it is on cabinets that the real triumphs of the cabinet maker's art are displayed.

3. Fixed Woodwork.

Thirdly, the joiner's and cabinet maker's art plays an important part in the fixed furniture of the house, and the woodwork, such as flooring, doors and door-frames, panelling, chimneypieces, with the complementary decorations of hangings, whether tapestry, silk, or the more humble material of paper.

In this last division of furniture the work is that of joinery. There is no great demand for constructive strength, as the work is fixed to walls; but as doors and shutters are swung to and fro continually, and subject to jars and strains, their stiles and rails, upright and cross-framing members, as well as the panelling that fills them, require well-seasoned timber and the most accurate workmanship: without these conditions the joints open, the panels shrink from the grooves in which the edges are held, and split, while the frame itself, if of unseasoned material, 'buckles' or twists, so that the door or shutter will no longer shut flat in its frame.

Panelling and fireplaces are, however, opportunities for the display of carving, inlaying, and gilding. The reader has seen carved room panelling, probably, in many old houses. In some of the municipal 'palaces' in Flanders, e.g. in Bruges, and in the old rooms of the Louvre in Paris, carved panelling of the utmost grace and perfection, some of it in groups of life-sized portrait figures, may be studied by the tourist.

Of work so rich and costly as this wood sculpture, it is perhaps hopeless to speak with reference to our modern houses, and in connection with the manufacture of furniture in this country, at least on any large or general scale of application. Still as such work, confined to the composition of fireplaces or sideboard backs, is still sculptured by Italian and French carvers, and has been sent to Universal Exhibitions of recent years, it must be considered a possible effort for our great employers of skilled labour.

The panelling of wall surfaces will be divided into larger or smaller reticulations or framework, with some reference to the size of the room, that is to say, that very large and lofty rooms will not bear the smaller subdivision of space and delicate moulding lines which are so general in panelling of mediæval or very early Tudor houses, and which are in keeping on walls of moderate size. Any inlaying or variety of woods should be used on walls with great discretion.

So far, then, on the general consideration of the work, which it is the business of the furniture maker to produce. In theory, it is his object to satisfy daily wants and necessities in the most convenient, useful, and agreeable way.

The difference between rudeness and refinement in daily habits consists in putting first order and propriety, then comeliness and cheerfulness into our homes and habits. There is so much to be borne and to be done merely that we may live, so many contradictions to natural inclination meet us on all sides, that we look for repose, and some moderate satisfaction to the natural desire of the eye, in that which meets it, and must meet it, so constantly. This satisfaction is beauty, or some measure of it, or what we have grown to take for beauty. As the eye is more exercised, the mind more informed, and becomes a better monitor or corrective to the eye, so we get less satisfied with much that passes for beauty, and so, on the other hand, we find it out in objects in which it is commonly or often passed over.

Manufacture.

A return prepared by the Commissioners for the Paris Exhibition, in 1867, gave the following as the number of manufacturers engaged in London in "the several branches of the fancy furniture trade."

Cabinet makers	812
Upholsterers	486
Carvers and gilders	342
French polishers	142
Cabinet carvers, inlayers, and liners	108
Bedstead-makers	43
Chair, sofa, and stool-makers	252

Wood and cabinet wares were exported (in 1865) to the value of 289,887*l.*, and imported to the value of 128,925*l.* [5]

The highest efforts of the trade are concentrated in a few large establishments in London and the great cities, which have their own cabinet makers, carvers, upholsterers, &c., on their premises. In some instances, one piece of furniture may pass through the hands of several branches of the manufacture. I may choose a few names of makers who presented their works in Paris in 1867 in alphabetical order, e.g. Messrs. Collinson and Locke, Crace, Dyer and Watts, Gillow, Herring, Holland, Howard, Hunter, Ingledew, Jackson and Graham, Morant, Trollope, Wertheimer, Wright and Mansfield. The larger of these establishments are supplied with steam machinery, and all the work that can possibly be executed by mechanical agency is prepared by these engines, leaving only the most costly operations to be executed by hand.

It is the province of the carpenter to put together simple woodwork; that which is an actual part of architecture, such as boxes, chests, benches, seats, shelves, and so forth as require only good material and neatness of hand in execution. The joiner and cabinet maker include this amount of skill as a foundation for their accomplishments, as a sculptor can block out a statue and a painter grind his colours, work, however, which in ordinary practice is handed over to assistants or apprentices.

Before discussing the materials and the methods of execution now in use, it would be well to notice a great change which has taken place both in the status of the workman, the division of labour, and the mechanical appliances now at his command.

Down to recent times, joinery and cabinet making were in the hands of a number of masters in the trade, far greater in comparison to the pressure of the demand on the part of buyers than is the case at present. We have a larger society of buyers, a greater demand for the execution of large orders at a rapid rate, than was the case in former generations. On the other hand, the trade is gathered up into fewer master hands. The masters then employed a less amount of labour. They took in apprentices, many of whom remained for years with them as assistants, and the establishment was more of a family. It followed, that all members of this smaller society worked together and took part in the particular sets of chairs, the tables, cabinets, and so forth, turned out from their own house. They were, moreover, animated in a closer and truer degree by the spirit, and adopted the ideas, of a master who worked with or overlooked and advised them constantly, than could be the case in our great modern establishments. Again, though, as I have already said, the old operations by which boards, bars, and other members of wood construction are joined together, have not substantially varied since the days of Egyptians and Romans, the methods of execution have undergone a great change, owing to the introduction of machinery. The skill and training of the hand of the workman must necessarily undergo a change as well, whether for the better or the worse. The workman is relieved from the necessity of attaining an absolute accuracy in much of the ordinary but essential work of joints, mortises and other operations which can be produced with an uniform exactness by mechanical means.

The fact, also, that different engines or lathes can produce at a prodigious rate certain separate parts of many pieces of furniture, has made skilled mechanics less universal "all round" men than they were. If this combination of qualities is to be met with in provincial towns or villages, there, without doubt, the standard of excellence is a lower one.

Materials and Execution.—The woods used for making furniture besides pines and deals, are birch and beech (used for stuffed chair-frames, couches, &c.) walnut, letter wood, Spanish and Honduras mahogany, sycamore, lime, pear, cherry of several kinds, and maple; ash, English, American, and Hungarian; oak, English, foreign, and pollard, with pieces cut from wens and sweet cedar. Turners use also plane, laburnum, yew, holly, and box. More precious woods are also used in furniture: rose-wood, satin-wood, ebony, and sandal-wood. Other rare woods are used in inlaying and marquetry.

Some of these materials, mahogany and walnut, which are much in use, are imported in vast logs, the former sometimes three feet square; when of very fine grain suited to veneers, worth 1000*l.* or more, per log.

The woods are stacked in yards, or, in London, where the space cannot otherwise be had, on platforms resting on the walls of the workshops, and fully exposed to the weather. Woods are dried after a year, or two years, according to the size of the log and nature of the wood. Oak is sometimes kept for eight or more years. When sawn into the scantlings required, it is further dried by placing the logs and planks in rooms heated by the waste steam from the engine. An American patented method of drying is to place a coil of pipes, through which exceedingly cold water is passed in the drying room, which condenses and carries off the vapours from the wood exposed to this heat. Some firms have tried this method, but, I believe, without much success.

Logs are cut up by the engine with three or more perpendicular saws at once, the teeth being set to the right and left alternately, to open a passage for the blades. More valuable woods, e.g. mahogany, are cut into thin plank by an horizontal saw. In this case the teeth are not bent, but a labourer opens the passage for the blade by lifting the plank with a wedge. As little waste of the material as possible is thus secured.

Further cutting up of the material is done by means of circular saws. Part of the saw rises through a metal table. A moveable bar is firmly screwed at one, two, or more inches from the blade, and the wood is pushed by the workman against the saw, keeping one surface against the fixed bar, so as to secure a straight cut of the thickness required. Most modern *planing* is done by a revolving cutter, brought to bear upon the wood, which is drawn under it on an iron table, with more or less pressure, according to the quantity to be taken off the surface. Messrs. Howard have contrived a tube with a blast down it, which carries the shavings at once to the furnace, otherwise the dust made by the flying particles of wood would be unendurable.

Mouldings for panelling, cornices, skirtings, &c., are cut by revolving cutters or chisels, filed to any desired shape and case-hardened. They are set in a perpendicular axle and cut horizontally, the wood being firmly pressed against the tool. The workman can gear the cutter or reverse the action, so as to make a neat finish to his work.

Formerly all such work was done with a plane, cut to the required figure, and the finishings of lines of moulding had to be carved with the hand.

Mortising is done by a revolving boring tool, against which the wood to be mortised is moved by a gradual action, from side to side, and backwards and forwards, till the exact depth and width are bored out; tenons fitting these cavities are cut in another lathe, also by mechanical action.

Turning lathes.—The legs of chairs and tables are made in lathes, the general outline being obtained by turning in the simple form. Portions of the legs are sometimes squared, and the square faces must be evenly graduated. These parts are cut as follows: the lathe and the leg in it are kept at rest, and a revolving tool—in fact, a small lathe with a perpendicular cutter in it, connected by a leather band with a spindle overhead—set in motion by the steam-engine. The workman passes this cutter carefully down the four surfaces of the portions to be squared, cutting to a given depth all down, but never losing the angle outlines originally found by the first turning. When flutings have to be cut down the legs, whether they are round or square, this is done by using a revolving cutter set with horizontal action, which passes carefully along at one level, and is geared by the joiner so as to graduate the width of each fluting, as it descends, if the diminishing size of the support or leg requires it.

Bars of chairs, edges of shelves, the stretchers (or connecting bars) under some kinds of tables, are cut into carved or other shapes by an endless band saw revolving on two rollers. The workman passes his wood along an iron table against the saw, gearing the former according to the pattern drawn on the surface.

Fretwork is done with a still finer hair or watch-spring saw, of which one end can be detached from the holder and passed through a small hole in the piece of wood where the piercing is to be cut out by the saw. This could not be done by an endless saw, which can only be used to shape out edges. The best saws of this description are made by Perin, in Paris.

Watch-spring saws strained in frames have long been in use. In the steam-engine it is the wood only that is moved, and as it rests on a steady table, it gives the workman a great advantage, and should enable him to shape out his design with a delicacy only attainable with greater difficulty by the old method.

The process of *mitreing* pieces of moulding, where they meet at an angle at a corner, is done by machinery in some houses. In the works of Messrs. Jackson and Graham, this is done by setting the pieces in a metal **T** square. They are carefully cut by hand, and as each piece is set in a frame geared to the angle required, and under the hand of an experienced workman, no inaccuracies are likely to occur. In cabinet-making and joinery of all kinds, the number of angles round which mouldings have to pass is very great, as anyone will see who is at the pains to notice the construction of furniture of the most ordinary kind. Any staring or opening of an oblique joint is destructive of the effect of such workmanship, as it is of the strength of the joint which is glued together, and requires absolute contact of the parts to be joined.

Much work, such as chair rails, table legs, balusters for little galleries or on a large scale, is turned and cut in the steam lathe by hand, using steam power only to turn it.

Joinery.—The pieces of wood thus prepared are made up in many different combinations. This is the work of the joiner. In the joiners' shop of Messrs. Jackson and Graham, for instance, several benches were shown to me occupied by lengths of wall-panelling in ebony, some of the work being intended to cover the wall of a staircase; it was therefore framed in sloping lines. Each panel was a rhomboid, and none of the sides or mouldings were at right angles to each other. The mouldings had several fine strings, ovaloes, &c., all specially designed by the architect of the house—as the fittings of well-furnished houses should be. For these, special cutters had been made and fitted to the steam-moulding machine. To show the back of the panelling, the workmen turned it over. Instead of each panel being held in a groove provided in the stiles and rails, a rebate only has been cut in the frame, and the panel fits into it from the back (as the stretcher of a picture fits into a picture-frame), while iron buttons screwed into the frame pieces hold the panels firmly in their places. The object of this is to allow for the contraction of the wood with the alterations of temperature. With some woods, however well seasoned, this provision is requisite, and it is the more necessary, when more than one material is employed. In using ebony over large surfaces, it is found that the lengths required for the continuous rails cannot be procured free from knots or faults; and particular kinds of wood (pear and other material) are stained and prepared, to supplement the ebony in these instances.

The joiners put together panelling, chairs, couches, frames of tables, shelves, cupboards, and other complex pieces of furniture.

Upholstery.—Chairs and sofas required to be stuffed are then handed over to the upholsterer, and the seats and backs are stuffed with curled horsehair, carefully arranged so as not to wear into holes. A *French edge* is given to some stuffed seats by bringing the edges of several ridges of horsehair together, so inclined towards the upper edge, that each roll receives support from the others, which react on the pressure thus brought upon them, like springs. One would suppose that these edges were maintained by whalebone, like the stocks in which a past stiff-necked generation suffered so much. Where ribbon scrolls, tiny bunches of flowers, &c., are carved on the frames and top rails of chairs and sofa-frames, if these are to be polished only, the polishing is done before the upholstery. If *parts* are to be gilt, or the *whole* gilt, these operations are postponed till the upholstery is completed. So also when panelling, sideboards, bookcases, &c., are to be made up, the moulded lines which can only be conveniently hand-polished while in lengths, are treated thus before making up; and there remain only flat panels and surfaces, that can be evenly rubbed for the final polishing. In upholstered furniture, the coverings would be greased and stained, if polishing were done over or in connection with them; but in the case of gilt work, it must be left in most cases to the last, for fear of dimming or rubbing the gold during the processes of sewing, nailing, stuffing, &c.

I may remark here, that though arm-chairs, fauteuils, &c., are made in great London establishments, the manufacture of light chairs on a large scale is a special branch of the trade, and mostly carried on at High Wycombe, in the neighbourhood of which town there are extensive woods of beech, and where land and water carriage is at hand to convey these productions to London and elsewhere.

Cabinet-making.—It is by no means easy to lay down the exact technical boundary between what I have been describing as *joinery*, and what I am now about to call *cabinet-making*. They are considered, however, as distinct branches or rather, perhaps, different operations of the trade; and in such establishments as we are discussing, the cabinet makers and joiners have their own separate workshops and benches, and corresponding separate repositories for storing and drying their woods. Every kind of work is required in making costly cabinets, bookcases, sideboards, commodes, or by whatever name we choose to call the beautiful chests, cupboards, and other artistic receptacles, tables, consoles, brackets, &c., that go to complete the requirements of our modern reception rooms.

They are seldom made with the quaint or elaborate interior fittings, such as have been alluded to in older work, but every resource is brought to bear on the external decoration. Here we come to the arts brought to bear on the ornamentation of furniture.

Let us begin with carving. Sculpture is the highest or most beautiful kind of decoration that can be applied to furniture. It can only be executed by a trained artist. To go no farther back here than the Italian and French Renaissance furniture, generally made of walnut-wood, it is the spirited and graceful sculpture that makes its *first* great attraction. The Italian carving of this kind is the most graceful; while that of France by Bachelier and others, and much that was executed in England and Germany, being, if less graceful, always spirited and thoroughly decorative. As a general rule, sculpture so applied is *conventional* in design and treatment, that is, we rarely see it, (except, perhaps, occasionally in little ivory statuettes, and in bas-reliefs,) strictly imitative of nature, like perfect Greek sculpture. But neither should we find strict studies from nature on Greek furniture, if we had it, except with the same limitations. The furniture made by Greco-Roman artists, and discovered at Pompeii, [6] bears witness to this assertion, such as a head, a bust, the claws of animals, sculptured on furniture generally ending in scrolls or leafwork. If a human figure is complete, it bears no real proportion to objects round it, and so on.

Excellent wood sculpture used to be executed in England, from the days of Grinling Gibbon to those of Adam and the Chippendales, suited to the furniture then in fashion. I wish I could say that our furniture makers of to-day could easily, or did generally, command such talents. Ingeniously carved representations of animals and game on sideboards we sometimes see, but game 'dead' in every sense. If, indeed, Messrs. Crace, Howard, Jackson and Graham, and other firms could persuade the Royal Academicians to model for them, those artists would have to give some material amount of time to the study of how they could so effectually modify their skill as to suit the requirements and opportunities of a piece of furniture, these being quite peculiar. The French are easily our masters in this respect, but even they sacrifice good qualities proper to this kind of sculpture, in a morbid search after the softness of nature.

A curious piece of mechanism has been invented, and is in use in most large London furniture workshops, for *carving by steam*. Besides boring out and cutting away superfluous material, there is an engine for making mechanical sculpture in bas-relief, or the round. The wood is fixed on a metal table, which is moved to and fro and up and down, so as to come in contact with a revolving cutter held above it. The wood is then shaped and cut, according as it is elevated or moved. There are three or four cutters, and one piece of wood may be placed under each. Under the middle cutter, replaced by a dummy tool that does not really cut, the workman places his cast or model, and makes the dummy cutter pass over every undulation of its surface. The two or three cutters on either side cut the corresponding blocks exactly to the same depths and undulations as are followed by the blunt tool. It is a *copying machine*. That such copies, though they may pass muster, will ever have the charm of original carving, the reader shall not be asked to believe.

Certain elaborate methods of decorating and finishing woodwork must now be described, viz. those known as *inlaying* and *marquetry*. These two processes are distinct, but marquetry furniture has often portions decorated with inlaying, as also carved ornaments and decorations of beaten, cast, or chiselled metal-work. This last addition is not generally of the same importance in our modern English woodwork that it was a century ago, and I will describe the former methods first.

Inlaying means the insertion of pieces of more costly wood, stone, small discs, or carved pieces of ivory, into a less valuable material. The process is as old as any manufacture in wood working of which we possess records. Beautiful plates or blocks of ivory can be seen in the Assyrian gallery of the British museum, found at Nineveh by Mr. Layard. They are deeply cut with lotus and other leaf decorations, figures and hieroglyphics, and most of them have an Egyptian character. The ivory figures, too, have been inlaid and filled up with vitrified material. Remains of these decorations are still discernible, and the thickness of many of these pieces of ivory shows that they have been sunk bodily into woodwork of a solid character.

No such work as this can be pointed out in our London workshops, but patterns and arabesques, both of wood and ivory, are occasionally let into solid beds of wood so deeply, as to be actually mortised into the main body of the structure. This is done both by our own makers and by the French cabinet maker, Henri Fourdinois, a prize piece of whose make was bought for the South Kensington museum. It is not uncommon to insert pieces of lapis lazuli, bloodstone, and precious marbles into centres of carved woodwork, and I may call attention to the use of plates, medallions and cameos of Wedgwood, or Sèvres ware, which were frequently inlaid by Chippendale, and by the great French furniture makers, or *ébénistes*, of the last century. These are used in the modern satin-wood furniture of Messrs. Wright and Mansfield, and I have lately seen a coarser material used, viz. bas-reliefs in *stoneware*, imitations of the *gris de Flandres*, by Messrs. Doulton. These last, however, may be said to be rather panels set in frames, than pieces let into cavities in wood.

Veneering and Marquetry.—An effective method of ornamenting woodwork by the application to the *surface* of other woods is what is known as *veneering* and *marquetry*. The surface is in both cases covered with a thin layer of other woods, fastened on with glue and by strong pressure. Some of the panelling, table tops, and other joiner's work already described, is clothed with a thin slice of more valuable wood. This is called *veneering*. Woods such as ebony, tuya, satin-wood, palm, hare-wood, and a number more, are only to be had in small scantlings, logs a few feet long, and six or seven inches wide. Other woods, of which the grain is most beautifully marked, are cut from roots, wens, and other excrescences of the trees, to which they belong, and are only found occasionally, and in lumps of no great size. The contortions of the grain, which make them so valuable and beautiful, are owing to peculiar conditions of growth. In all these cases an inch plank of wood has to be cut into very thin slices, twelve being cut with a saw, or from eighteen to twenty-two if it is cut with a knife, as in that case no material is wasted by the opening made by a saw. These slices are laid on the surface of well-seasoned wood, and in the workshops of our great manufacturers will be seen a metal table or bed, prepared expressly for the process of veneering.

Supposing the object to be veneered to be a large surface—a number of panels, or the top of a table of ebony, for instance—the substance of the table may be Honduras mahogany. The wood has been carefully seasoned, and the top grooved, tongued, and firmly glued up to the required form. The ebony surface is also carefully fitted together and glued on paper, the surface being left rough, so that the glue may have a firm hold on the fibre of the grain. A corresponding roughness is produced on the upper surface of the mahogany, which is then laid on the metal bed. Glue, perfectly fluid and hot, is now rapidly brushed over the entire surface, and the thin veneer top is laid upon it, and firmly pressed down by several workmen, who then carefully go over the whole with hammers having broad, flat heads; the object of this being to flatten any apparent thicknesses of glue or bubbles of air which would interfere with the perfect contact of the two surfaces of wood. The whole is then placed under a caul or frame that touches it all over, and a number of strong bars are screwed down till the greater part of the glue has been pressed out. The complete union of the surfaces of the woods is effected not so much by the quantity of glue as by the absolute exclusion of the air, and this can only be done by pressure. The whole metal bed or frame in which the veneering is performed is heated by steam, or by gas-burners, where steam cannot be applied. The wood is left for twenty-four or thirty hours, till the glue has been completely set and hardened. The caul or frame is then removed, the paper used to keep the thin veneer together before gluing is scraped off, and the work of finishing and French polishing takes place. French polish, or careful wax polish, has the effect of keeping out air and damp, which latter might soften the glue and disintegrate the surface veneer. It is to be observed, that such wood as the finest French or Italian walnut is often veneered on mahogany, for it lasts better in this condition than if it was solid; large surfaces and thicknesses of walnut being difficult to procure without faults. Walnut veneers are applied in greater thicknesses than ebony; and if the surfaces to which they are applied are curved, cauls, or shaped pieces of wood made to fit them, are screwed down and held by numerous wooden vices, as in the method already described.

Marquetry is the application of veneer made of different woods, ivory, &c., composed like a mosaic or painting executed in coloured woods. This kind of decoration is of ancient use, was much in vogue during the Renaissance of the fifteenth and sixteenth centuries, and was carried to a great pitch of perfection in France during the seventeenth and eighteenth. It is still practised, and the process may be seen in full activity in the workshops of our modern furniture makers. In cutting out the forms required for marquetry decoration, one, two, or more thicknesses of thin wood are gummed or pasted together, according to the pattern required. In many fine pieces of marquetry there are, as in the case of a cabinet or table, portions of the surface entirely occupied by quiet reticulated patterns. As in these cases the same pattern often recurs, several thicknesses of wood can be laid together, and are then firmly fixed in a vice, having pasted over them a piece of paper on which the pattern is drawn. A small hole is bored where it will not interfere with the design, and the end of a thin watch-spring saw is passed through, and then re-attached to the frame that strains it out in working order. With this in his hand, the workman carefully traces the outlines of his drawing, which the tenuity of the saw-blade allows the tool to follow into every curve and angle. The thicknesses are then separated with the blade of a knife, and the slices become alternately pattern and ground, so that a set of patterns and a set of matrices of each wood are ready for use, and can be applied either on different parts of the same, or on two separate pieces of furniture. If a flower or other ornament is required which will not be repeated, two thicknesses only will be cut together. It is necessary that the same action of the saw should cut out the pattern and the ground in the two woods required, so that they may fit exactly.

When all the portions of the design are cut out, they are pasted on paper, and can be fitted together like mosaic. A little sawdust from the woods used, and a very small quantity of glue, join the edges and fill up the fine openings made by the saw; and in this way the whole surface of the marquetry is laid down on paper. In the case of flowers, heads, architectural or other designs, some slight additions, either of lines to indicate stalks, leaf-fibre, or the features of the face, are made with a graver, and stained; or gradations of a brown colour are given, in the case of white or light-tinted wood, by partial burning. It was formerly the custom to burn with a hot iron, but a more delicate tint is given by using hot sand, and this is the best method of tinting beech, lime, holly, box, maple, or other woods which are nearly white. There remains nothing but to rough the surface of the furniture, and to lay down the marquetry on it, precisely as in the case of plain veneering. When the glue is dry and hard, the pressure is taken off, the paper which is on the outer surface is scraped away, and the whole rubbed down to a fine surface and French polished. The most beautiful work of this description was made in France by Riesener and David, during the reigns of Louis XV. and Louis XVI. Besides graceful and delicate *design*, which these artists (for such they were) thoroughly understood, the beauty of their work owes much to their charming feeling for colour. Both used light woods, such as maple, holly, box, lime, &c., and laid brown woods, such as laburnum and walnut, on this light ground. Sometimes architectural compositions in the manner of Pannini, a favourite Roman painter of the day, were designed over the doors or flaps of secrétaires and cabinets, or busts, medallions, baskets of roses, &c. The charm of the work is the grace and repose with which these simple decorations are laid on. Compare some of the work of Riesener and David, on the cabinet doors in the collection of Sir Richard Wallace, with the glaring contrasts, the gaudy, often discordant colouring, and the crowded compositions of modern marquetry, at least of most of it. There is a tenderness of treatment, a grace and harmony of colour and arrangement throughout the former, which is wholly wanting, and which no lapse of time will add to the latter. Though these criticisms are not meant to be applied to the products of the leading houses now under review, the reader who has taken an observant stroll amongst the furniture of Sir Richard Wallace, at Bethnal Green, will find abundant contrasts as he walks along the streets of London.

In order to illustrate my remarks on the processes of colouring woods by burning or etching, I may point to a large writing bureau, or secrétaire, belonging to Sir Richard Wallace, made by Riesener, in 1769 (and signed), for Stanislaus, king of Poland. It is decorated partly with reticulated pattern work, partly with the royal cipher in medallions, and with other medallions containing emblematic figures, such as a carrier pigeon, a cock, the emblem of vigilance, or the head of a girl placing her finger on her lips, an emblem of silence. All these medallion figures are broadly drawn, the very slightest and most delicate tint only being added to represent shading, while the drawing is a single line lightly pencilled.

The materials used in the best marquetry are lime, holly, box, maple, beech, poplar, for white; pear, laburnum, palm (cut across the grain), lignum vitæ, walnut, teak, partridge-wood, for brown; wood called in the trade fustic, satin-wood, for yellow; tulip, purple-wood, amboyna, mahogany, thuya, log-wood, cam-wood, and varieties of these woods, for red; ebony for black, or stained wood. Greens and blues are also stained with metallic dyes. The finest of the old work may be called studies in brown and white, and the red woods are used sparingly; the dyed woods still more so, nor can they be said ever to be really effective.

As an example of great mechanical skill in a modern piece of very difficult execution, I might call attention to Messrs. Jackson and Graham's elaborate cabinet of marquetry, in patterns of Oriental character, after designs by the late Mr. Owen Jones (sent to the Vienna Exhibition by Messrs. Jackson and Graham). It had an architectural front, with detached columns and groups of architectural mouldings, some of them put together with the lines of moulding in woods of contrasted hue, an element of ornamentation that took from the unity and completeness of cap or corona mouldings. The little columns of an inch and a half diameter were entirely covered with reticulated pattern in different woods. As the shafts were tapering, so the reticulated patterns had to be graduated in size from top to bottom. This was a feat of most difficult execution, nor was it the only difficulty in this portion of the design. The marquetry in the instance of these columns had to be wrapped round each circular shaft; and each edge, therefore, of every portion of pattern and groundwork had to be sawn out with bevelled edges, so that when rolled, the inner edges might meet and the outer edges remain in contact, which would not be so, were they not bevelled: the contrary would happen in that case, and the outer edges would start in sunder. These columns were two feet and some inches high, and the little reticulations of pattern recurred many dozens of times. The conditions of which I speak had to be carefully observed in the case of each. The pattern, too, was graduated, as above stated, so that they had to be sawn out by separate cuttings—a most laborious and costly operation.

We miss in the great English houses one of the most costly and beautiful elements in the adornment of furniture, and that is, the fine moulded and chiselled bronze work, always gilt, which enters so largely into the decoration of fine old French marquetry. The English furniture makers of a century ago were not so behindhand, and old carriages had door-handles, and furniture had mounts of gilt bronze. Probably the French were always superior to us in this kind of skill. They still produce good work of this class, cast and afterwards cleaned and tooled with the chisel, but it is not equal to the work of the same description by Gouthière, and the famous *ciseleurs* of Paris in the last century.

I must not pass over in silence a beautiful kind of furniture which was in fashion a century since, and has been revived by Messrs. Wright and Mansfield, and other firms, viz. satin-wood furniture. In the time of Chippendale, Sheraton, Lock, and other great cabinet makers, contemporaries of the French artists Riesener, Gouthière, and David, satin-wood was imported from India. It was made up by veneering, and was decorated with medallions, some of marquetry, some of Wedgwood ware, after the model of the French inlaying of Sèvres porcelain plaques, and in some instances painted with miniature scenes like the Vernis Martin, called after a French decorator of the name of Martin. Old examples of satin-wood furniture, such as tables, bookcases, chests of drawers, &c., are not uncommon, decorated in one or more of these methods. Cipriani and Angelica Kauffmann were employed amongst many others in painting cameo medallions, busts, Cupids and so forth for satin-wood furniture. Messrs. Wright and Mansfield have executed much of this work, and sent a cabinet of large size to the Paris Exhibition of 1867, decorated with medallions, swags, ribbons, &c., partly in marquetry of coloured woods, partly in plates of Wedgwood ware. The piece is further set off by carved and gilt portions, not, however, sufficiently attractive to add greatly to the effect of the whole cabinet, which is gay, cheerful, of beautiful hue, and excellent workmanship. It is in the South Kensington Museum.

Allusion has been made to the furniture of Boulle. It began to be made somewhere about 1660, and was perhaps the earliest start taken in the more modern manufacture of sumptuous furniture. I have already called it a great advance and improvement, rather than an absolutely new invention, for pieces are found of a date too early to have been the actual work of Boulle. When the tortoiseshell is dark and rich in hue, the brass of a good golden yellow, and the designs carefully drawn, Boulle work seems to equal in splendour, though not in preciousness, the gold and silver furniture of the ancients, and the inlaid work of agates, crystals, amethysts, &c., with mounts of ivory and silver made in Florence in the sixteenth century.

Boulle work is made occasionally by French and other foreign houses, and by Wertheimer of Bond street, but it is costly, and the rich relieved portions, such as the hinge and lock mounts, the salient medallions, masks, &c., set in central points of the composition, are either copies or imitations of old work. They lack the freshness, vigour, and spirit of the old French metallurgy.

A spurious kind of Boulle is made with a composition in place of the tortoiseshell.

Parquet floors are made by Messrs. Howard as follows: Slices of oak, varied sometimes with mahogany, walnut, and imitation ebony, are laid out and put together on a board. If rings, circles or other figures are introduced, these portions, patterns, and cavities as well as angular pieces are cut in the machine. The thickness of these pieces is a quarter of an inch. They are then laid on three thicknesses of pine, the grain of each thickness being laid crosswise to the one below, so as to keep the wood above from warping and opening. These are glued together, and kept for twenty-four hours under an hydraulic press. It is, in fact, coarse marquetry, and the whole is laid down over a rough deal floor. Messrs. Howard also glue up their quarter inch hardwoods without a pine backing, and lay them down with glue and fine brads on old deal floors, a less expensive method, and which can be adopted without raising the level of an old floor.

It is remarkable that English cabinet makers should so rarely make these floors, or architects lay them down in rooms of modern houses. The French, Germans of all states, Swiss, Belgians, in short most continental nations have these floors, and Swiss and Belgian flooring is imported into England. That of the Belgian joiners is in large pieces four feet or so square, of seasoned wood, moderate in price, and easily laid down.

In this country, our costly modern houses are barely provided with a border of a foot or so round the edges of the reception rooms. Even that is but an exceptional practice. Yet oak flooring is not a costly addition to important rooms, while the habit of keeping floors always covered with Brussels carpet tacked down is not the cleanest imaginable.

Another application of veneered wood practised by Messrs. Howard is called by them "*wood tapestry*." Very thin slices are arranged geometrically in large patterns, and fastened with glue on staircase and passage walls, or made into dado panelling to the room, in this case capped by mouldings.

An ingenious method of inlaying thin veneers on flat surfaces of wood by machinery has been patented by the same firm. Veneers or slices of wood about the thickness of coarse brown paper are glued on a board, e.g. a table top. A design punched out in zinc, of a thickness somewhat greater than that of the veneer, is laid over it, and the board is then placed under a heavy roller. The zinc is forced into the surface of the board by the roller to about the thickness of the veneer. A plane cleans off the rest of the veneer, leaving the portion only that answers to the zinc pattern, thus forced into the surface of the board. If soaked, the grain of the wood would push up the thin veneer, no doubt, but this is no greater risk than that to which all marquetry is exposed.

Neither of these inventions have as yet been carried beyond the simplest disposition of arrangement. What can be done in either method remains to be shown.

All the woodwork passed under review thus far in joinery and cabinet-work, is of *hard* woods. Much, however, of our modern furniture is of a less valuable description, and is made of pine, American birch, Hungarian and other ash. Pitch-pine, an exceedingly hard wood, difficult to dry, and with a disagreeable propensity to crack if not very well seasoned, is also used, and a beautiful material it is. Some small quantity of bedroom furniture in beech, oak, and ash is made in the workshops that I have been describing. As a general rule, however, this manufacture of soft woods is a separate branch of the trade. To see soft wood, such as pine, made up into admirable bedroom furniture, and French polished till the grain of it shows much of the delicacy and agreeableness of satin-wood, we should pay a visit to the works of Messrs. Dyer and Watts, in Islington, and to other houses that occupy their time exclusively in work of this kind. It is clean, cheerful, and, by comparison, cheap; is ornamented (in the works of Messrs. Dyer and Watts) with neat lines of red, grey, and black, some of the lines imitative of inlaid wood. It is popular, and if we proceed from the workshops of Messrs. Graham, Holland, and others, to their showrooms and warehouses, we shall find this deal furniture for sale, though they do not profess to make any of it. Less costly pine-wood furniture is painted green, or white, or in imitation of other woods.

The surface of woodwork, if the woods are valuable, is finished by *French polishing*. A solution of shell-lac is put on a rolled woollen rubber, which is then covered with a linen rag, on which the polisher puts a drop of linseed oil. He rubs this solution evenly over the entire surface of the wood as it passes through the fibre of the linen, smooth action being secured by the oil. It is laid on in successive fine coats till a glossy surface is obtained which is air and water-proof. For fine work the surface should not be so glossy as to look like japan work. French polishing preserves woods liable to split, such as oak, from the too rapid action of the air.

Graining is an imitation of oak or other woods. A light colour, chrome yellow, and white, is first laid on, and glazed over with brown. While still wet, the brown is combed with elastic square teethed combs to give the appearance of graining. Larger veins are wiped out by the thumb and a piece of rag. All sorts of woods are thus imitated, and the work when dry is varnished over. Independently of any skill or deceptiveness, this broken painted surface looks effective and lasts long.

Of the propriety of such a decoration there are many doubts, for the discussion of which there is not space here. Marble graining has long been represented in Italy, e.g. in the loggia of Raphael in the Vatican. But in that particular instance, the painting is a *representation*, not an *imitation*. Wood graining is performed in all countries, and such imitations seem to have been practised by the ancients.

Mr. Norman Shaw is now exhibiting in Exhibition road examples of woods with fine grain stained green, red, and other colours, and French polished, the grain showing as if the woods were naturally of those hues.

For inexhaustible resource in tinting, polishing, and decorating wood surfaces, we shall have to learn from the Japanese, from whom probably the famous Vernis Martin was first borrowed in the last century. Much imitation lac-japanning was executed in this country during the latter years of the century. This work is still made in Birmingham. Pieces of mother-o'-pearl are glued on wood and the intervening surface, covered with lac varnish which is rubbed smooth, coat after coat, with pumice and water, till the surface of the inlaid pearl shell is reached, and the whole ground to a glassy polish.

London Factories.

The number of hands employed in large cabinet-making and furnishing establishments is very considerable. Not only are the workshops well provided with joiners, cabinet makers, and turners, but also with upholsterers, cutters-out and workwomen, stuffing, tacking on or sewing on the covers of chairs, sofas, &c. Indeed, it is no uncommon occurrence for the entire furniture of royal palaces and yachts to be ordered from one of these firms by the courts of foreign potentates in every corner of the world. Chairs, tables, sideboards, &c., were made lately at Messrs. Holland's for a steam yacht of the Emperor of Austria; while Messrs. Jackson and Graham have been furnishing the palace of the Khedive at Grand Cairo.

To execute, with certainty and promptitude, orders such as these, both premises, plant (such as wood and machinery), and the command of first-rate hands, must be abundant. Painters, gilders, carpenters, paperers, and a miscellaneous assistant staff are required to pioneer the way for the more costly work, or to make all good behind it. The firm of Jackson and Graham, for instance, employs from 600 to 1000 hands, according to the time of the year or the pressure of orders; and pays out close upon 2000*l.* per week as wages, when all these hands are in full work; and to highly skilled craftsmen (independently of designers), occupied on the production of the most costly kind of furniture, 60*l.* to 230*l.* per week. The Howards employ from 150 to 200 hands on cabinet making and joinery alone. It is the variety and comprehensiveness of these operations, that is so profitable as a speculation. Such a business requires, it need hardly be said, a large capital, and must be liable to fluctuations.

The Past and the Future.

A few words must be given to a retrospect of the state of this branch of the national industry, and to its prospects. If we look back twenty-five years to the furniture exhibited in London in 1851, the improvement of the present time seems incredible.

We may take that Exhibition, the first of these modern displays of all sorts of products of labour, as a point of departure for our review.

In 1851, the Commissioners directed that a complete report should be drawn up on the subject of the decorative treatment of manufactures of all kinds, including the particular class of objects under discussion. The author of this report calls attention to what should be the first consideration, in the construction of objects for daily and personal use. From the continual presence of these things, "defects overlooked at first, or disregarded for some showy excellence, grow into great grievances, when, having become an offence, the annoyance daily increases. Here at least utility should be the first object, and as simplicity rarely offends, that ornament which is the most simple in style will be the most likely to give lasting satisfaction." [7] Yet on examining the furniture on the English side, the reporter could not but notice, how rarely this very obvious consideration had been attended to. "The ornament of such works on the English side consists largely of *imitative* carving." Ornaments consisting of flowers, garlands of massive size and absolute relief, were applied indiscriminately to bedsteads, sideboards, bookcases, pier-glasses, &c., without any principle of selection or accommodation. "The laws of ornament were as completely set aside as those of use and convenience. Many of these works, instead of being useful, would require *a rail to keep off the household*."

These strictures were far from being applicable to the entire British Exhibition of this class of work. One or two notable exceptions may be quoted, such as a bookcase carved in oak, exhibited by Mr. Crace, bought by the Commissioners and added to the Kensington collections. This and a few other works "are particularly to be commended for their sound constructive treatment, and for the very judicious manner in which ornament is made subservient to it. The metal-work is also excellent, and the brass fittings of the panels of the bookcase deserve to be studied, both for the manner in which they have been put together and for their graceful lines."

Four years later, in 1855, in the Paris Exhibition, our furniture and woodwork had made a stride forward, which was still more marked in the London Exhibition of 1862. By that time, our leading houses had appreciated the necessity of obtaining talented designers and foremen, and in many instances they had employed the first architects of the day to give them drawings. The result was a great progress. While the French, indeed, continued to produce very fine pieces, some on the best models, or rather after the principles of the best periods of the Renaissance, our own cabinet makers had run far on in the same direction and in many others, for the mediæval feeling had still a strong hold on the taste of English architects and their patrons.

The greatest change, however, was that which the Paris exhibition of 1867 brought to light. Fifteen full years had passed, since public attention had been called to any careful comparison between the state of our furniture and the decorations of the interiors of our houses, with those of other countries, and the advance was incalculably greater on the part of this country than on that of the other competing nations.

It is worth remarking, that in three great comparative Exhibitions, and particularly in that of 1867, national tastes and peculiarities seemed to have been so completely pared away, that it became difficult to keep the productions of the North and West of Europe from those of the South or the East, distinct in one's mind. Each nation followed the fashion of the works that had obtained the best prizes at former Exhibitions.

For the present, French Renaissance designs in woodwork, and the produce of the looms of Lyons in hangings, serve to give the key to the school of domestic and industrial art in this country. If we look at the richest and most costly productions that have been exhibited, and carried off prizes at the International Exhibitions of late years (and we have no other standard of easy comparison), it will be found that French cabinets, tables, and chairs have served as models to the successful competitors. Indeed, the most successful of such pieces of furniture are actually designed by French artists in some of our leading firms. There is a decided English type in the satin-wood furniture of Messrs. Wright and Mansfield, and there is some invention, though not always happy, about our designers of mediæval furniture. These productions are, however, too apt to be heavy and ecclesiastical, to follow rather the types of stone constructions, and the teachings of the admirable plates of Viollet-le-duc, than the lighter work, inaugurated, not without power and success, by Pugin. There is a company of artists, Morris and Co., who have combined painting and woodwork, and produced excellent results; but they have had few followers, or rather few successful followers. I cannot but mention with honourable commendation the Royal School of Art needlework, as a subsidiary branch of furniture art.

So far as to the past. With regard to the future some few remarks may not be out of place: on the excellence of workmanship, the propriety of design, and the beauty of decoration.

The altered conditions of a trade such as that of the cabinet maker, which combines the useful with the agreeable, comely, and beautiful, in its productions, have been alluded to already. This change must seriously affect the accomplishments of the workman. Instead of working under and with his master, he is become one of a regiment of officials. He cannot identify himself with the entire work of which he only executes members interchangeable with other members, all mechanically alike. Again, mortises, tenons, dovetails, and joinery of all sorts, no longer demand from hand-work the accuracy, neatness, and perfection of former days. These operations are done for him. Occasionally he supplements the work of the engine. Like a player who only plays music occasionally, we cannot expect him to retain all the fineness of his hand in perfection.

Is the modern workman, then, the equal of those of sixty years since, whose productions stand so well to this day, because of this perfection of manual dexterity? It will be difficult to maintain that he is, but it would be most unjust to deny either that the best workmanship can be turned out, or that it is turned out, of our great establishments. This is the work of the most choice and accomplished hands. In smaller London houses, and in the furniture which we find in the trade generally, the workmanship is inferior, relatively, to that of the former period.

The introduction of machinery, however, is a fact, and its effects on manual skill must be accepted as a necessity. Nor must we pass over the further fact, that if the modern joiner is not the equal of the journeymen of Chippendale, he can *do more*. He has powers at command, and can carry into execution quantities, beyond the reach of half-a-dozen, perhaps a score of his predecessors. The consumer ought to reap advantages from this latter fact which he has failed hitherto to get, as shall be explained presently.

This brings me to the consideration of the proprieties of design, and the beauty of decoration of our present furniture. If workmanship is affected by altered conditions of the manufacture, so also is design, that union of effective and suitable decoration with the required convenience of each piece of furniture, which may be called *style*.

The artist, as regards his productions or style, is fashioned partly by what he thinks and loves, partly by his materials and his tools. With some materials he can do little, for want of tools and appliances. As regards material, wood remains what it always has been, but the steam-engine supplies an absolutely new set of tools. What has been done with them? The impressed marquetry has been mentioned, but as yet nothing really new has been done by the use of machinery. Thin veneers which might be cut out with scissors, as if one were cutting paper in inexhaustible fulness and variety, are restricted, in this impressed marquetry, to such as can be copied in the coarse material, zinc, which has to be punched or sawn out for the manufacture. Then again we have the carving or copying machine. At present nothing more is done with it than to copy, and to copy somewhat clumsily, in duplicate or in large numbers, that which has first been carved or modelled by hand. It would be premature to decide, that with so powerful a tool in his hand, an accomplished artist trained to use it, could not produce real and rapid sculpture. But no such artist has yet stepped on the stage, and it can only be an artist who can put the matter to a proof.

In following the style and ornamentation of former periods, our new machinery is in no sense a help to us. The man who cuts out his material for a Sheraton chair *felt* what he was going to carve upon, chose his pieces, arranged the grain, and the spare material just as he would require it, with careful reference to the use of his carving tools from first to last. *The pace*, too, required in executing orders was then more deliberate; costly and elaborate plant and machinery not being required, provincial workmen of admirable skill were to be found in many towns. There is no royal process by which we can put a log of wood into one end of an engine, and find a chair, a table, or a cabinet at the other. What steam machinery does for us is to perform with certainty, and with immense rapidity, the simple operations of sawing, planing, boring, and turning. It is by turnery that ornamentation is done in the engine. Any length of moulded edges can be soon turned out, any amount of the parts of panelling, of turned rails, and of ornaments turned on flat surfaces pressed on the cutting tool, together with the piercing of fretwork and curved and shaped edges to boards. The saw being a fixture in this instance, is an advantage, but machine turnery is not rich in resources. The tool itself is filed laboriously to the mould required, and the wood merely pressed against it. When the wood revolves (as in the old lathe), the turner, with the simple edge of his chisel or his gouge, was the master of an endless variety of ornament limited only by his fancy or skill of hand.

It is nevertheless in the turnery and the fret-cutting machinery, that a furniture artist must find the elements of a style. The man of genius, the poet and maker, who can throw himself into these elements, will do wonders with them. The lathe is as old as history. During the sixteenth, seventeenth, and eighteenth centuries, turned wood furniture was made in considerable quantities in this country, in Italy, and in the Indian possessions of the Portuguese. All the furniture of Arabs, Moors, and Turks springs from the lathe and the moulding plane; the tables and stools, the ingenious reticulation of Cairene geometrical panelling, the screens of woodwork so effective in the queen of Arab cities and in Damascus are derived from these humble sources.

To surface ornament of marquetry, occasional carved insertions can be added. But light, neat, and elegant woodwork, panelling, bookcases, cabinets, dressers, chairs, and tables, can be turned out without these additions, and the variety might be endless.

Carved acanthus foliage, bulging legs and surfaces, artistic carving and marquetry, and chiselled metal-mountings must be the work of trained sculptors. The engine gives them no real help. To design, that is invent (not to copy), carving and marquetry that will bear comparison with the products of Riesener, and of the school of Gibbons, is not to be done by command of appliances or skilful workmanship *only*. The artist who is thoroughly at home in designs of this kind, is the pupil or descendant of masters whose traditions are well established:

"Fortes creantur fortibus."

But neat furniture, unornamented by hand-work, ought to be turned out of the engine-room, the perfection of lightness, convenience, and strength. And here the buyer will look for the advantage of *cheapness*. We do not find that our large makers supply well-made machine furniture *cheap*. As a broad rule, prices seem to be calculated on *what a man would do*, and work done in the machine is priced, as if a man had made it by hand. In point of fact, five or six men's work is done in the same time, and the cost of wages charged on articles so made, will leave a disproportioned profit, notwithstanding the expense of setting up and maintaining the steam plant.

Decorative furniture can never be had at a cheap rate.

A word, in conclusion, as to the arts which are necessarily pressed into the service of furniture, and their prospects of the future.

These "sumptuary" arts have been spoken of in these pages as a revival in furniture and *style*, as dead. The disorders that culminated in the French revolution cut off our present European thoughts, or at least our manners and customs, from the past.

We are now trying to revivify past traditions. The furniture makers have made extraordinary exertions in this direction. How will it be in the coming years?

Some critics are of opinion that "art manufacture" is a delusion, and that, if our academicians were equal to the ancient Greeks, we should not find that rich buyers would care about the shapes of their chairs (if comfortable), the colours of their walls, and so forth—a singular delusion. If Phidias, Michael Angelo, and Raphael exhibited at Burlington House, their pupils and followers would overflow with good work in various degrees of elaboration. We should find it in our churches, houses, seats, carriages, and the rest. This is what *did* happen when the great artists were flourishing. Ugliness and vulgarity were not endurable anywhere. Mentor expressed himself in drinking cups, Cellini in brooches, Holbein in daggers, Michael Angelo in a candlestick, Raphael culminated in a church banner. The art that finds its utterances on knobs, or handles, or drawer fronts, is restricted certainly, because the object is of awkward shape or surface, is to be handled and used, and is only a part of something larger. Nevertheless the street of tripods in Athens, the front of the *biga* in the Vatican, were "occasions" on which good sculptors did the best that those occasions allowed of. Four fine silver images, representing four great provincial capitals, in the Blacas Collection (now to be seen in the British Museum), were perhaps the ends of the poles of a Sedan chair.

Objects of this kind, though fragmentary, or slightly worked out, or combined in some grotesque but graceful fashion, with a piece of leaf or stalk, are the easy results of long years of mental and manual training.

The workman artist, therefore, though his productions may not be thought suitable for the Academy walls, is a child of the same school, as that which brings forth such portents as Phidias, Praxiteles, Michael Angelo, and Leonardo, not to speak of our Royal Academicians.

Artists who are "specialists," like Giovanni da Udine, will continue to do special things only, but those admirably. Where the arts flourish, there will be a large school that includes half a nation, artists of all ranges of education, refinement, and knowledge. Some will sculpture figures for the temple, others will be of the rank of workmen. Vasari has given full details of the sumptuous furniture which was executed by the sixteenth century Academicians of Florence.

How are we to procure such teachings? This was the question which Colbert put to himself in the reign of Louis XIV. He resolved it, by getting masters and teachers of every kind of sumptuary art from Italy. The result has been to give the French nation a lead in this kind of industry, that holds good even amidst the ruin of old traditions, at this day.

The Kensington schools, and those on the same pattern throughout the country, are efforts made by the Government to meet the wants of our manufacturers. They are inelastic, and it is too soon to judge of the work they are likely to do hereafter. The only great error in such education would be to train scholars to be "ornamentalists," i.e. *to teach them conventional art*.

Art is conventional in connection with architecture and furniture, because in most instances this is all that would be proper or look well. A good modeller, draughtsman, or carver, would become conventional just as occasion required, but with no abstract desire for ugliness or the grotesque. That artists should be generally well educated and good scholars, and that the profession should possess knowledge and refinement, is of more importance than most people suppose. This kind of refinement lay at the root of the universality of accomplishments of the sixteenth century artists.

Lastly, it is not enough that the profession only should be educated, so as to supply the manufacturer with designs. It is the rich that must be taught as well. We are neither Italians nor Frenchmen, and, indeed, speaking generally, we have not so much sense of beauty and propriety in art as those races have, even with such degeneracy as prevails but too widely over the Channel.

It is enough to look at modern London, to listen to the disputes of committees of management or selection for a public monument, a street, or a gallery, and to take a glance at their choice, to see what we are in these respects. But Englishmen are not wanting in genius, and in the matter of which these pages treat, they have played their part well in the past.

When buyers know what is ugly, they will not tolerate it about their houses; the eagerness to possess something new or original will give place to a just judgment of what is good, whether new or old. Most periods of good sumptuary art owe their designs to a few old types constantly reproduced under new and agreeable varieties, that are not radical changes. To know good from bad in these matters, is the result not of a natural instinct altogether, but of such a sense instructed by study, experience, and reflection. Nor, on the other hand, does such an instinct accompany great intellectual acquirements naturally, and as a matter of right. A man may possess a vast amount of learning, statesmanship, or professional knowledge, and be no judge of painting, sculpture, marquetry furniture, or blue porcelain. Nor, though he knows something of the history of these objects, will he necessarily admire and like the best or most beautiful examples. It is this sense of what is becoming, that has to be learned, though it is occasionally a natural gift. When whole nations have become used to good domestic art, public opinion will be sound, and will perpetuate itself as regards this subject matter, till some great national convulsion reduces sumptuous living, and refined social manners and habits, to ruin.

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Footnotes

[1] These numbers are approximate translations of the numbers given in the communication: no object could be gained in giving complex fractions.

[2] 1 ounce avoirdupois weighs 28·349 grammes.

[3] 1 mètre equals 39·37 English inches.

[4] 1 kilogramme = 2·2 lbs. avoirdupois.

[5] Cat. Brit. Section Exhibition, 1867, Introduction, p. 61.

[6] See also Q. de Quincy, Le Jupiter Olympien.

[7] Supplementary Report, chap. xxx.

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