UNIVERSAL SCIENCE,

OR THE

CABINET OF NATURE AND ART:

COMPRISING ABOVE ONE THOUSAND

ENTERTAINING AND INSTRUCTIVE

FACTS AND EXPERIMENTS,

SELECTED FROM VARIOUS

DEPARTMENTS OF NATURAL PHILOSOPHY,

AND THE

USEFUL DISCOVERIES IN THE ARTS.

ILLUSTRATED BY NUMEROUS ENGRAVINGS ON WOOD.

IN TWO VOLUMES.

VOL. II.

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LONDON:

PRINTED FOR G. & W. B. WHITTAKER,

13, AVE-MARIA-LANE, LUDGATE-STREET.

1821.

Printed by R. Gilbert, St. John's Square, London.

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MANUFACTURES.

UNIVERSAL SCIENCE.

CHAPTER I.

ARCHITECTURE.

SECTION I.

INTRODUCTION.

ARCHITECTURE is the art of building generally, but without any appellation denotes the erection of houses. From the remotest times mankind seem to have practised this art, as we learn from the construction of the Tower of Babel.

The ancient eastern nations, surpassed the moderns, in the greatness of their structures, as is manifest from the descriptions we have of the Tower of Babel—the Walls of Babylon, its hanging gardens, and its temple of Jupiter Belus, which rose a mile high, eight several stories, and on the top of which was the Astronomical Observatory;—the vast rock cut into the figure of Semiramis, with the smaller rocks that lay by it in the shape of tributary kings; and, finally, the prodigious bason, which received the whole Euphrates, until a new canal was formed for its reception, with the several trenches through which that river was conveyed, are ample proofs of the vastness of ancient architectural structures.

The original of all buildings may be deduced from the construction of the meanest huts. These were, at first, made in a conical figure, which is the simplest in structure, but being inconvenient on account of its inclined sides, both the figure and construction of the huts were changed, by giving them the form of a cube. Mankind at length improved in the art of building, and invented methods of rendering their habitations durable and convenient. The trunks of trees deprived of their bark and other inequalities of surface, were raised above the humid soil, by means of stones, and covered each with a flat stone, or slate, to exclude the rain, and the interstices between the ends of the joints, were closed with wax or clay. The roof was altered and elevated in the centre by rafters, to support the materials of the covering, and to carry off the water.

When the rude builder erected more stately edifices, he imitated those parts which, from necessity, had composed the primitive huts. The upright trees, with stones at each end, became the origin of columns, bases, and capitals; and the beams, joists, and rafters, which formed the covering, gave rise to architraves, friezes, and cornices.

The Greeks, whose genius prompted them to combine elegance and convenience, derived their ideas of building from the Egyptians. But the mind of man is influenced by the government under which he lives; the Greeks, with their independence, lost the ascendency in works of genius, and from that period the Romans encouraged this noble art. Vitruvius, the learned Roman architect, had Julius Cæsar and Augustus for his patrons, and though employed in few works of magnificence, his rules for architecture were highly esteemed by the ancients, and are still a standard among the moderns. The Romans carried to the highest perfection the five orders of architecture. The Tuscan, the Doric, the Ionic, the Corinthian, and the Composite; and though the moderns have materially improved the general structure of buildings, nothing has been added to the beauty and symmetry of these columns.

SECTION II.

DIFFERENT ORDERS OF ARCHITECTURE.

1. The Tuscan order has its name and origin in Tuscany, first inhabited by a colony from Lydia, whence it is likely the order is but the simplified

Doric. On account of its strong and massive proportions it is called the rustic order, and is chiefly used in edifices of that character, composed of few parts, devoid of ornament, and capable of supporting the heaviest weights. The Tuscan order will always live where strength and solidity are required. The Etruscan architecture is nearly allied to the Grecian, but possesses an inferior degree of elegance. The Trajan column at Rome, of this order, is less remarkable for the beauty of its proportions, than the admirable pillar with which it is decorated.

2. The Doric order, so called from Dorus, who built a magnificent temple in the city of Argos, and dedicated it to Juno, is grave, robust, and of masculine appearance, whence it is figuratively termed the Herculean order. The Doric possesses nearly the same character for strength as the Tuscan, but is enlivened with ornaments in the frieze and capital. In various ancient remains of this order, the proportions of the columns are different. Ion, who built a temple to Apollo in Asia, taking his idea from the structure of man, gave six times the diameter of the base for the height of the column. Of this order is the temple of Theseus at Athens, built ten years after the battle of Marathon, and at this day almost entire.

3. The Ionic order derived its origin from the people of Ionia. The column is more slender than the Doric, but more graceful. Its ornaments are elegant, and in a style between the richness of the Corinthian and the plainness of the Tuscan; simple, graceful and majestic; whence it has been compared to a female rather decently than richly decorated. When Hermogenes built the temple of Bacchus, at Teos, he rejected the Doric after the marbles had been prepared, and in its stead adopted the Ionic. The temples of Diana at Ephesus, of Apollo at

Miletus, and of the Delphic oracle were of this order.

4. The Corinthian, the finest of all the orders, and as first used at Corinth, is expressive of delicacy, tenderness, and beauty. The invention of the elegant capital with which it is adorned, has been attributed to Callimachus, who seeing a basket covered with a tile over the root of an acanthus plant which grew on the grave of a young lady, was so struck with the appearance, that he executed a capital in imitation of it, in which the tile was represented by the abacus, the leaves of the acanthus by the volutes, and the basket by the body of the capital.

The entablature was much enriched by introducing in the frieze, representations of groupes of figures. When the entablature is thus ornamented, the columns are fluted. The most perfect model of the Corinthian order may be found in the three columns in the Campo Vaccino, at Rome, the remains of the temple of Jupiter Stator. This order marks an age of luxury, when pomp and splendour had become the predominant passion, but had not yet extinguished a taste for the sublime and beautiful.

5. The Composite order, invented by the Romans, partakes of the Ionic and Corinthian orders, but principally of the latter, particularly in the leaves of the capitals. This order shews that the Greeks had, in the three original orders, exhausted all the principles of grandeur and beauty; and that it was not possible to frame a fourth but by combining the former.

SECTION III.

GOTHIC ARCHITECTURE.

6. Gothic is a general term for that kind of architecture formerly used in England, and on the

continent. But the ancient buildings in this country are divided into Saxon, Norman, and Saracenic. When the Romans invaded Britain, they found no places corresponding with our ideas of a city, or town. Dwellings, like those of the ancient Germans, were scattered over the country, generally situated on the brink of a rivulet for the sake of water, or on the skirt of a wood or forest, for the purpose of hunting and supporting their cattle. These inviting circumstances being more conspicuous in some parts of the country than in others, the princes and chiefs selected the most agreeable spots for their residence.

7. When the Romans formed settlements and colonies in this island, a remarkable change took place in the style of architecture. They not only built solid, convenient, and magnificent edifices for their own accommodation, but also exhorted and instructed the Britons to follow their example. Soon after this, however, architecture, and the arts connected with it, declined in Britain. This arose, perhaps, partly from the building of Constantinople, which attracted the most celebrated architects to the east; but the almost total ruin and neglect of architecture in this island, may doubtless be attributed to the final departure of the Romans. The natives, and the descendants of Roman and British parents, having neither skill nor courage to defend their numerous towns, forts, and cities, suffered them to be plundered and destroyed by their ferocious invaders, the Scots, Picts, and Saxons; who having no taste for the arts, committed the most wanton and extensive devastations.

8. The Saxon architecture was the Roman architecture in a decayed state. The Saxons having the Roman buildings continually before their eyes, employed workmen to build their edifices in a similar manner.

The style of building practised throughout Europe was of this kind, and so continued to be used by the Normans, with some trifling alterations, till the introduction of the Saracenic architecture about the reign of Henry II. The characteristics of Saxon architecture, are, the semi-circular arch, and short, thick, massive columns. It has no pinnacles or pointed ornaments, no delineations of arms, nor statues, except in relief. The best specimen of this style is the north transept of Winchester Cathedral.

9. The Norman architecture differs from the Saxon chiefly in its increased proportion, and in the magnitude and massiveness of its buildings, arches highly ornamented with figures of angels, fruit, animals, &c.—subjects serious and ludicrous promiscuously blended together, walls without buttresses, arches supported by solid, clumsy pillars, with a regular base and capital; the capitals adorned with carvings of foliage and animals; the columns with small half columns joined to them, the surfaces ornamented with spirals, squares, network, and figures in relievo.

These may be seen in the monastery of Lindisfarn in Holy Island, the cathedral at Durham, the ruined choir at Orford in Suffolk, and in the crypt or under-croft of Canterbury Cathedral.

10. Saracenic or Gothic architecture had numerous and prominent buttresses, lofty spires and pinnacles, large and ramified windows, ornamental niches and canopies, with sculptured saints and angels, delicate lace-work, fretted roofs, and an indiscriminate profusion of ornaments.

The fret-work is so called from the Saxon word *frættan*, signifying fishes' teeth. But its most distinguishing characteristics are small clustered pillars and pointed arches, formed by the segments of two intersecting circles. This style was of Arabian origin, introduced into Europe by the Crusaders; or those who made pilgrimages to the Holy Land. In the reign of Henry III. many of the old buildings were pulled down to give place to new ones on this model. The cathedral of Salisbury was begun early in this reign, and finished in 1258. It is one of the finest productions of ancient architecture in this island, and is completely and truly *gothic*. This term, however, has been abused; and is employed, by the ignorant, to designate the mongrel labours of common builders.

11. Florid Gothic. Edward I. in 1290, on the death of Eleanor, to shew his respect to the memory of his queen, caused a magnificent cross to be erected at every spot where her body and the funeral procession halted. Most of these crosses, which have since been destroyed, were profusely decorated with sculptured ornaments; at Northampton, Geddington, and Waltham, the most perfect yet remain.

This kind of workmanship was adapted, by its richness, for screens and altar-pieces. Elaborate canopies, ornamented pinnacles, octagonal niches and stalls, with the crocket ornament stealing up the angle, the pyramidal point crowned with a large flower, or pine-apple; pendant decorations of fruits, flowers, and emblazonry seen in all parts; sculptures of small imageries in the fretted roofs of the principal aisles and chancels, characterise this style.

The thirteenth century must be considered as the grand epocha of Gothic luxuriance, when the combination of ornament and profusion of decoration had been extended over the whole building. Among the principal erections in this and the succeeding centuries, may be reckoned the nave and western front of York cathedral—the whole of Lichfield cathedral—a transept of Canterbury cathedral—our Lady's chapel at Ely—Merton, and New College, Oxford—St. Stephen's Chapel, Westminster, now the Commons House of Parliament; with additions and alterations to several other cathedrals. Henry the Seventh's chapel at Westminster is particularly worthy of admiration, from the wonderful skill exhibited in its structure. The use of stained glass in the cathedral windows, was another addition to their beauty, and completed that solemn effect so necessary to be preserved in religious edifices. Foreign artificers were first employed to glaze the monastery of Weremouth, in 647. The figures of kings and prelates were represented in painted windows as well as in sculpture. The most ancient specimens now existing are in the cathedrals of Canterbury and York, and in the chapel of King's College, Cambridge. The eastern window of St. George's chapel at Windsor, is the finest specimen among our modern attempts. At the western painted window in the church of Batalha, in Portugal, the fathers usually assemble in the choir to chaunt the evening service, whilst the myriads of variegated rays which emanate from this beautiful window, resemble so many beams of glory playing around them.

During the thirteenth and fourteenth centuries, most of the exteriors of our Saxon and Norman churches were transformed into the Gothic, which completed the victory of this, over every other style in the kingdom. From the end of the fourteenth century, no remarkable variation can be discovered. Gothic architecture, at this period, had been at its height for nearly two centuries. When Henry VIII. began the reformation, and the dissolution of monasteries took place, the two universities were at first included in the general ruin; these edifices, however, sacred to science as well as to religion, were saved from that dilapidation which many of the monasteries and cathedrals experienced. The desolating hands of those reformers who succeeded Henry VIII. destroyed many of the most beautiful specimens of this style of architecture, and despoiled them of their most beautiful ornaments. *Castellated* Gothic was generally used in that age, when the feudal system rendered it necessary that noblemen should possess fortified castles. This style resembles the original Saxon and Norman architecture.

SECTION IV.

MODERN ARCHITECTURE.

12. Gothic architecture began to decline from the time of Henry VIII. A style in which the Grecian and Gothic were mixed together then prevailed, but in the sixteenth and seventeenth centuries the chaste architecture of the Greeks and Romans was revived. The first improvements took place in Italy, whence they passed into other parts of Europe; and though the Italians were long accounted the first architects, England produced Inigo Jones and Sir Christopher Wren, who hold the most exalted station.

The banqueting-house at Whitehall, queen Katherine's chapel at St. James's; the piazza of Covent Garden, and many other public buildings are monuments of the taste and skill of Inigo Jones.

The churches, royal courts, stately halls, magazines, palaces, and public structures designed by Sir Christopher Wren, are proud trophies of British talent. If the whole art of building were lost, it might be again recovered in the cathedral of *St. Paul*, and in that grand historical pillar called the *Monument*. To these we superadd *Greenwich Hospital, Chelsea Hospital, the Theatre at Oxford, Trinity College Library, and Emanuel College, Cambridge*; the churches of *St. Stephen in Walbrook, St. Mary-le-bow, and* FIFTY-TWO *others in London*, serve to immortalize his memory. While we contemplate these, and many other public edifices erected and repaired under his direction, we are at a loss which most to admire—the fertile ingenuity or the persevering industry of the artist.

The architectural history of the eighteenth century differs from that of preceding ages in two essential circumstances.

1. The *public* buildings, erected during this period, are, in general, not so grand and massive as those of some former periods. But while they fall short of splendour and magnificence, they are superior to most ancient structures in simplicity, convenience, neatness, and elegance.

2. *Private Dwellings* have been made more spacious, convenient, and agreeable to a correct taste, than in any preceding period. The liberal use of *glass*, in modern buildings, contributes greatly to their beauty and comfort, and is a point in which the ancients were totally deficient. In descending to the various minute details of human dwellings, especially those which have reference to elegance and enjoyment, it is obvious the artists of the eighteenth century exceeded all others.

SECTION V.

ARCHITECTURAL ORNAMENTS.

13. **Balusters** are pillars of wood, stone, &c. used to ornament the tops of buildings, and to support railing: when continued, they form a balustrade.

Caryatides, figures of women dressed in long robes after the Asiatic manner, to support entablatures in buildings. Other female figures have been used for a similar purpose, but the original name is still retained.

A war had been carried on by the Athenians against the Carians; the latter were totally vanquished, their wives were made captives, and to commemorate this event, trophies were made by the Athenians, in which figures of women, habited in the Caryatic manner, were used for the purpose just explained, and this is in fact the origin of this part of architecture.

Persians, so called from a victory gained over the Persians by Pausanias, who having brought home prisoners, spoils, and trophies to the Athenians, they chose Persian male figures to support the entablatures which have been changed in the same manner as the Caryatides. Persians may be of any size, the larger the greater the effect which they impress on the spectator's mind. In arsenals, galleries of armour, &c. they are advantageously used.

Pilasters, have their bases, capitals, and entablatures, the same as those of columns, but are square, not round as columns are.

A *portico* is a range of columns covered at the top; that of Palmyra was 4000 feet long.

Termini, figures anciently used to mark the limits of possessions, are still used in the human shape as ornaments for temples and garden edifices.

SECTION VI.

ARCHITECTURAL MONUMENTS.

14. Among the various arts which conduce to the civilization and comfort of man, there is scarcely any which, on the one hand, presents such fragile, and, on the other, such durable productions as architecture. For what can be more frail than the huts which savages construct out of the limber branches of trees? what more permanent than those structures of granite and of marble which seem to defy the ravaging waste of time, and in the magnitude of their ruins, hand down to posterity some faint memorial of the greatness of mind possessed by the monarchs who commanded them to be erected, and of the artists' ingenuity who reared them so massive and of substances so well calculated to resist the destroying elements? Without, however, wasting words on a subject that needs no arguments to prove, nor the production of any facts to illustrate its truth and importance, we will at once, begin our studies of architectural monuments.

But it may not be altogether out of place to observe that in the selection of the subjects of this study, we have attended to the antiquity of some, the fame of others, and the singularity of a third class. Thus we have endeavoured to present this subject, as a well skilled artist would exhibit a model, of three façades, any one of which being accidentally or intentionally offered to the spectator's view, should be capable of arresting his attention and gratifying his wishes.

No subject is of more historic antiquity than the Tower of Babel; there is none that arrests our early attention more keenly, and none which, in after life, we think of with more reverence when association is busied in comparisons between modern and ancient monumental structures.

15. *Remains of the Tower of Babel.*

It is a pleasing thing to observe the coincidence which subsists between ancient historical accounts of the architecture, manners, and customs of the East, and the more recent ones of scientific travellers.

In Genesis, the account of the building of this immense structure is as follows: "and it came to pass, as they journeyed from the East, that they found a plain in the land Shinar; and they dwelt there. And they said one to another, go to, let us make brick, and burn them thoroughly. And they made brick for stone, and slime had they for mortar. And they said, one to another, go to, let us build us a city and a tower, whose top may reach unto heaven; and let us make us a name, lest we be scattered abroad upon the face of the whole earth."

Mr. Rich, a recent traveller, has favoured the world, with a very interesting description of this tower as it stands at present. After suggesting, that the intention of building the Tower of Babel might be partly *monumental;* but principally to answer the purposes of astronomical observation, we shall give Mr. Rich's account in his own words:

"The whole height of the Biro Nemroud (the Tower of Babel) above the plain to the summit of the brick wall is two hundred and thirty-five feet. The brick wall itself which stands on the edge of the summit, and was undoubtedly the face of another stage, is thirty-seven feet high. In the side of the pile a little below the summit is very clearly to be seen part of another brick wall, precisely resembling the fragment which crowns the summit, but which still encases and supports its part of the mound. This is clearly indicative of another stage of greater extent. The masonry is infinitely superior to any thing of the kind I have ever seen; and leaving out of the question any conjecture relative to the original destination of this ruin, the impression made by a sight of it is, that it was a solid pile, composed in the interior of unburnt brick, and perhaps earth or rubbish; that it was constructed in receding stages, and faced with fine burnt bricks, having inscriptions on them, laid in a very thin layer of lime cement; and that it was reduced by violence to its present ruinous condition. The upper stories have been forcibly broken down, and fire has been employed as an instrument of destruction, though it is not easy to say precisely how or why. The facing of fine bricks has partly been removed, and partly covered by the falling down of the mass which it supported and kept together.

Obs. If such be the history of the architecture of Babel, a single monument, what must the ancient city of Babylon have been, if we may form an estimate of its magnificence from the following account unembellished by fiction and vouched by the veracity of antiquity.

16. *Ancient City of Babylon.*

Babylon, the capital of Chaldæa, and one of the most ancient cities in the world, is said to have been founded by Belus, and embellished by Semiramis, the war-like queen of the East, and afterwards to have been repaired, enlarged, and beautified by Nebuchadnezzar. It is described by Herodotus as situated in an extensive plain, forming a perfect square, which is bisected by the Euphrates running from north to south; each side is eighteen miles in length, and the whole compass above seventy-two. It was also surrounded by a wide and deep ditch full of water, and a wall three hundred feet in height and seventy-five in width.

The earth or clay dug out to form the ditch was made into bricks, and after being baked in a furnace served to compose this enormous rampart; and, at every thirtieth course of bricks a layer of heated bitumen and reeds was introduced. The side of the ditch was also lined or faced with the same materials; and at the top of the wall, opposite to each other, were erected small towers of one story in height; between which, a chariot and four horses could pass and turn. Along each bank of the river ran a wall, less high than the outer one, but of great strength, and which joined the outer walls where they formed an angle with the river. In the centre of the western division of the city was a large and well fortified space: on this side the hanging gardens were situated, and on the opposite bank stood the temple of Jupiter Belus, whose enormous gates of brass were still seen in the time of Herodotus; the square inclosure around the temple measured a mile in circumference, and in the midst of this space rose an immense tower, on which was placed another, and on the second a third, and so successively to the number of eight, each successive turret diminishing in size. On the outside were winding stairs, to ascend from one tower to another; in the middle of the ascent were seats, to allow such as mounted to rest themselves. In the highest tower was a chapel, which contained the bed of the mistress of the god; lower down, another chapel, in which was a golden statue of Jupiter.

The Euphrates winds gently by artificial canals, a considerable distance above, at Anderica, but ran straight through Babylon; at a breadth of five stadia.

Obs. As in these volumes it is more our object to present the most magnificent productions of nature and art, a number of similar subjects admitting of a resemblance in their description, would be less agreeable to the reader than a faithful account of the most striking in each class; and therefore among the labyrinths of antiquity we select that of Egypt.

17. *The famous Labyrinth of Egypt.*

Of all the labyrinths of antiquity, that of Egypt, was the largest and most costly. It was so extraordinary, that Herodotus who saw it says, that it far surpassed the report of fame, being in his judgment, even more admirable than the Pyramids.

The labyrinth of Egypt stood near Arsinoe or the city of Crocodiles, a little above the lake Moeris. It was of a square form, each side a furlong in length, built of most beautiful stone, the sculpture and other ornaments of which posterity could not exceed. On passing the outward inclosure, a building presented itself to view, surrounded by an arcade, every side consisting of four hundred pillars.

This structure seems to have been designed as a pantheon, or universal temple of all the Egyptian deities, which were separately worshipped in the provinces. It was also the place of the general assembly of the magistracy of the whole nation, for those of all the provinces met here to feast and sacrifice and to judge causes of great consequence.

For this reason, every province had a hall or palace appropriated to it; the whole edifice containing, according to Herodotus, twelve; Egypt being then divided into so many kingdoms. Herodotus says, that the halls were vaulted, and had six doors opening to the north, and six to the south, all encompassed with the same wall; that there were three thousand chambers in this edifice, fifteen hundred in the upper part, and as many under ground; and that he viewed every room in the upper part, but was not permitted, by those who kept the palace to go into the subterraneous parts; because the sepulchres of the holy crocodiles, and of the kings who built the labyrinth were there. He reports that what he saw seemed to surpass the art of man; so many exits by various passages, and infinite returns, afforded a thousand occasions of wonder. He passed from a spacious hall to a chamber, from thence to a private cabinet; then again into other passages out of the cabinets, and out of the chamber into the more spacious rooms. All the roofs and walls within were incrusted with marble, and adorned with figures in sculpture. The halls were surrounded with pillars of white stone finely polished; and at the angle, where the labyrinth ended, stood a pyramid which Strabo asserts to be a sepulchre.

This labyrinth stood in the midst of an immense square, surrounded with buildings at a great distance; the porch was of Parian marble, and all the other pillars of marble of Syene; within were the temples of their several deities, and galleries, to which was an ascent of ninety steps, adorned with many columns of porphyry, images of their gods, and statues of their kings, of a colossal size; the whole edifice consisted of stone, the floor being laid with vast flags, and the roof appearing like a canopy of stone; the passages met, and crossed each other with such intricacy, that it was impossible for a stranger to find his way, either in or out, without a guide; and several of the apartments were so contrived, that on opening the doors, there was heard within a noise like thunder.

The solidity of this wonderful building was such that it withstood, for many ages, not only the ravages of time, but that of the inhabitants of Heracleopolis, who, worshipping the Ichneumon, the mortal enemy of the crocodile, which was the peculiar deity of Arsinoe, bore an irreconcileable hatred to the labyrinth, which served also for a sepulchre to the sacred crocodiles, and therefore they strove to demolish it. Pliny says, it was remaining in his days; and that about five hundred years before Alexander, Circummon, eunuch to king Nectabis, was reported to have bestowed some small reparations on it, supporting the building with beams of acacia boiled in oil, while the arches of square stone were erecting.

Obs. From the earliest antiquity the Egyptians have been considered the inventors of the arts; and in the time of their prosperity all nations sought and studied their philosophy and their sciences; so that being learned in all the arts of the Egyptians became a common proverb. The labyrinth we have been threading is one of those wonders which still remain of this polished people, and the following account of the temples of Ebsambul and Karnac are but another portion of those magnificent works of architecture which consume ages ere they crumble to dust under the irresistible hand of time.

18. *Egyptian Temples of Ebsambul and Karnac.*

Among the interesting discoveries made by M. Belzoni, the excavation of these temples forms a principal feature. The following are his own details.

" From Thebes, I went up towards Nubia, to examine the great Temple of Ebsambul, which is buried more than double its height in the sands, near the second cataract. There I found the inhabitants very ill-disposed towards my projects, and from whom I prepared to encounter some difficulties. However, the season being too advanced, was my sole motive in deferring this enterprise to another time.

"In the mean time I returned to Thebes, where I occupied myself in new searches at the Temple of Karnac. There I found, several feet under ground, a range of sphinxes about forty in number, surrounded by a wall. These sphinxes, with heads of lions on the busts of women, are of black granite, of the usual size; and, for the most part, of beautiful execution. There was, in the same place, a statue of Jupiter Ammon, in white marble, holding a ram's head on his knees.

"After this I again took the road to Nubia, where some severe trials awaited me. The people of this country are quite savages, without any idea of hospitality. They refused us things the most necessary; entreaties and promises had no effect on them. We were reduced to live upon Turkish corn soaked in water. At length, by dint of patience and courage, after twenty-two days persevering labour, I had the joy of finding myself in the Temple of Ebsambul, where no European has ever before entered, and which presents the greatest excavation in Nubia or in Egypt, if we except the tombs which I have since discovered at Thebes.

"The temple of Ebsambul is 152 feet long, and contains fourteen apartments, and an immense court, where we discovered eight colossal figures thirty feet high. The columns and the walls are covered with hieroglyphics and figures very well preserved. This temple has then been spared by Cambyses, and the other ravagers who came after him. I brought some antiquities from thence; two lions with the heads of vultures, and a small statue of Jupiter Ammon."

At the end of the sanctuary he found four sitting figures about twelve feet high, cut out of the natural rock and well preserved. Belzoni's labour may be conceived, when we state, that on commencing his operations the bed of loose sand which he had to clear away, was upwards of fifty feet deep. From the superior style of sculpture found in this temple, to any thing yet met with in Egypt; M. Belzoni's coadjutor, Mr. Salt, infers that the arts descended hither from Ethiopia.

Obs. If such be the opinion of Mr. Salt, we may ask whether the arts did not travel from some country further east than Ethiopia is west of Egypt? "'Tis mere conjecture, some will say, to imagine the Asiatics taught the Egyptians." Be it so; still Asia produces astonishing monuments of architectural skill. And since the most effectual method of comparison is to place side by side, the objects on which you would form a judgment; we have chosen to give the following account of the temple of Elephanta, a place beside those of Ebsambul and Karnac.

19. *The Temple of Elephanta, near Bombay.*

THE following intelligent account of this subterraneous temple, is related by Mrs Graham.

Elephanta, is a mountain isle with a double top, wooded to the summit. Opposite to the landing-place is the colossal stone Elephant, from which the Portuguese named the place. It was mutilated by these adventurers. It must have been carved out of the rock on which it stands, for it appears too large to have been carried to its present situation.

After passing a village, we ascended the hill through romantic passes, sometimes overshadowed with wood, sometimes walled by rocks, till we arrived at the Cove. We came upon it unexpectedly, and I confess that I never felt such a sensation of astonishment as when the cavern opened upon me. At first it appeared all darkness, while on the hill above, below, and around, shrubs and flowers of the most brilliant hues, were waving in the full sunshine. The entrance is fifty-five feet wide, its height is eighteen, and its length about equal to its width. It is supported by massy pillars, carved in the solid rock. The capital of these resembles a compressed cushion, bound with a fillet; the Abacas is like a bunch of reeds supporting a beam; six of which run across the whole cave; below the capital the column may be compared to a fluted bell, resting on a plane octagonal member placed on a die, on each corner of which sits Hanuman, Ganesa, or some of the other inferior gods.

The sides of the cavern are sculptured in compartments, representing persons of the mythology; but the end of the cavern, opposite to the entrance, is the most remarkable. In the centre, is a gigantic Trimurti, or three formed god; Brahma, the creator, is in the middle, with a placid countenance; his cap is adorned with jewels. Vishnu, the preserving deity, is represented as very beautiful; his face is full of benevolence, his hands hold a Lotus, the same sacred flower is placed in his cap, with the triveni or triple-plaited lock, signifying the rivers Gunga (Ganges), Yamuna, (Jumna), and Seraswati, and other ornaments referring to his attributes. Siva frowns; his nose is aquiline, and his mouth half open; in his hand is his destructive emblem, the Cobra capella; and on his cap, among other symbols, a human skull, and a new born infant, marks his double character of *destroyer* and *reproducer*. These faces are all beautiful; but for the under lips, which are remarkably thick. The length, from the chin to the crown of the head, is six feet; the caps are about three feet more. No part of the bust is mutilated but the two hands in front, which are quite destroyed. Concealed steps behind Siva's hand lead to a convenient ledge, or bench, behind the cap of the bust, where a Bramin might have hidden himself for any purpose of priestly imposition.

On each side of the Trimurti is a pilaster, the front of which is filled up by a figure fourteen feet high, leaning on a dwarf; these are much defaced. To the right is a large square compartment, hollowed a little, carved into a great variety of figures, the largest of which is sixteen feet high, representing the double figure of Siva and Parvati, called Viraj or Ardha Nari, half male, half female, the right side of which is Siva, and the left his wife; it is four-handed; the two lower hands, (one of which appears to have rested on the Nandi), are broken; the upper right hand has a cobra capella, and the left a shield. On the right of the Viraj is Brama, four-faced, sitting on a lotus; and on the left is Vishnu, on the shoulders of Garuda. Near Brahma, are Indra and Indranee on their Elephant, and below is a female figure, holding a chamara or chowree *. The upper part of the compartment is filled with small figures, in the attitudes of adoration.

On the other side of the Trimurti, is a compartment, answering to that just described. The principal figure is Siva; at his left hand, stands Parvati, on whose shoulder he leans; between them is a dwarf, on whose head is one of Siva's hands, and near Parvati, is another. Over Siva's shoulder hangs the zenaar, and he holds the cobra capella in one of his four hands. He is surrounded by the same figures which fill up the compartment of the Veraji; his own height is fourteen feet, and that of Parvati is ten.

All these figures are in alto-relievo, as are those of the other sides of the cavern, the most remarkable of which is one of Siva in his vindictive character; he is eight handed, with a chaplet of sculls round his neck, and appears in the act of performing the human sacrifice. On the right hand, is a square apartment, with four doors, supported by eight colossal figures; it contains a gigantic symbol of Maha Deo, and is cut out of the rock like the rest of the cave. There is a similar

* A whisk to keep off flies, made of peacock's feathers, or ivory shavings, set in a handle.

chamber in a smaller and more secret cavern, to which there is access from the corner next to the Viraji; the covering of the passage has fallen in; but, on the other side, there is a little area which has no outlet, and is lighted from above, the whole thickness of the hill being cut through. The cavern, to which it belongs, contains nothing but the square chamber of Maha Deo, and a bath at each end, one of which is decorated with rich sculptnre.

The pillars and sculptures of the cave are defaced in every part, by having the names of most who visit them either carved or daubed with black chalk upon them, and the intemperate zeal of the Portuguese, who made war upon the gods and temples, as well as upon the armies of India, added to the havoc of time, has reduced this stupendous monument of idolatry, to a state of ruin. Fragments of statues strew the floor; columns, deprived of their bases, are suspendedfrom the parent roof, and others without capitals, and sometimes split in two, threaten to leave the massy hill that covers them, without support.

The temple of Elephanta, and other equally wonderful caverns in the neighbourhood, must have been the work of a people far advanced in the work of civilized life, and possessed of wealth and power; but these were lodged in the hands of a crafty priesthood, who kept science, affluence, and honours, for their own fraternity, and, possessed of better ideas, preached a miserable and degrading superstition to the multitude.

Obs. We said, in introducing the reader to the article he has just perused, that we chose to place it beside the descriptions of the temples of Ebsambul and Karnac, since a more just estimate of the respective characters of each would thereby be formed; and in this view also we take leave to exhibit the Palace and Temple of Balbeck. The history of its relicts will enable us to conjecture what it must have been ere the barbarism of man bequeathed it to the ravages of time.

20. *Palace and Temple of Balbeck.*

BALBECK, (the ancient HELIOPOLIS, or city of the Sun,) is the wonder of Syria.—It is situated in a delightful plain, on the west foot of Mount Antilibanus. Towards the south-west of the city, is a temple, with the remains of some other edifices; and, among the rest, of a magnificent palace. Near to these venerable ruins is a rotunda, encircled with

Corinthian pillars, which support a cornice that runs all round the structure. This rotunda is mostly of marble, and, though round on the outside, is an octagon within, being adorned with eight arches supported by Corinthian columns, each of one piece: it appears to have been covered and embellished with the figures of eagles. The Greeks have converted this into a church, and have spoiled its beauty, by daubing it over with plaster. Near this rotunda is a lofty pile of building, through which is seen a noble arched portico, 150 paces long, leading to the temple.

This temple is still almost entire: it is in its general form and proportions, like St. Paul's, Covent Garden; but, in dimensions and magnificence of structure, there is scarcely any comparison. Its length on the outside is 192 feet, and its breadth 96: its length in the inside is 120 feet, and its breadth 60. The ante-temple took up 54 feet of the 192; but it is now in ruins; and the pillars which supported it, are broken. The whole temple is surrounded by a noble portico, supported by Corinthian pillars six feet three inches in diameter, about 54 in height, and each is composed of only 13 stones. Their distance from each other, and from the wall, is nine feet. There are 14 of them on each side of the temple, and eight at each end. The architrave and cornice are exquisitely well carved; and between the wall and the pillars, there is a solid arcade, all the way, of great stones hollowed out arch-wise. In the centre of each of these is a god, a goddess, or hero, struck out with that life that can hardly be conceived; and all around the foot of the wall of the temple itself, is a double border of marble, the lower part of which is a continued bas-relief in miniature, expressing mysteries and ceremonies. Here, without the least confusion, is seen a surprising mixture of men and beasts, in the most happy composition, and most agreeable variety.

The entrance to the temple is truly grand; the ascent to it is by thirty steps, on each side bounded by a wall that terminates in a pedestal, on which formerly stood a statue. The front is composed of eight Corinthian fluted pillars, and an ample and nobly proportioned triangular pediment. Within these eight pillars, at the distance of about six feet, are four others like the former; and two of three faces each, that terminate the walls which come out a good way from the body of the temple itself. All these form a portico, in depth about 24 feet, and in breadth 60; through these pillars appears the door of the temple, with great majesty; so nice are the proportions of the pillars, their distance from each other, and the recess of the door itself. The portal is square, and of marble. Its whole height is about 40 feet, and its width about 28, with an opening of about 20 feet wide. Under this portal, the bottom of the lintel is enriched with a piece of sculpture, hardly to be equalled. It is a vast eagle in bas-relief, expanding his wings, and carrying a caduceus in his pounce; and on each side of him is a Fame, or cupid, supporting one end of a festoon by a ribbon, the other being held in the eagle's beak.

The inside of the temple is divided into three aisles, two narrow on the sides, and one wide in the centre, being formed by two rows of fluted Corinthian pillars, between three and four feet diameter, and in height, including the pedestal, about 36.

These pillars are 12 in number, six on a side, at the distance of about 18 feet from each other, and about 12 from the walls of the temple. The walls are adorned with two rows of pilasters one over another, and between each two of the lowermost is a round niche about 15 feet high. The bottom of the niches are upon a level with the bases of the pillars, and the wall to that height is wrought in the proportion of a Corinthian pedestal, and the niches themselves are Corinthian in all their parts, with the strictest precision, and nicest delicacy. Over these round niches is a row of square ones between the pilasters of the upper order: the ornaments belonging to them are all marble, and they are each crowned with a triangular pediment.

Towards the west end of the middle aisle, 13 steps, which are the whole breadth of this part, lead to a choir, as it is called. Here are two large square columns, adorned with pilasters, which form a noble entrance, exactly corresponding with that of the temple itself. The whole of this part is adorned with a great profusion of astonishing sculpture; but the pillars have no pedestals, and the niches stand upon the pavement. The two large square pillars, are thought to have supported a canopy; but nothing of that kind is to be seen now.

In the bottom of this choir is a vast marble niche, where stood the principal deity here worshipped. And throughout the whole are seen the most finely imagined sculptures of festoons, birds, flowers, fruits; bas-reliefs, Neptune, Tritons, fishes, sea gods, Arion and his dolphin, and other marine figures.

The ceiling, or vault, of this temple, is bold, and divided into compartments filled with excellent carvings. It is open towards the middle; but whether a cupola or lantern stood there for the admission of light, or whether it was always open, cannot be judged at this distance of time. In a word, the charming symmetry, and the correct taste, even at such elevations where so great niceness is thought unnecessary, are such, that it may be truly said, the whole pile is without the least blemish.

The whole stands upon vaults of such excellent architecture, and so bold a turn, that it is thought that they served for something more than merely the support of the superincumbent weight, and may have been a subterranean temple, applied to some particular service in the Pagan worship.

Though this temple now stands by itself, there are evident marks that it was accompanied by other buildings, no way unworthy of it; among which are reckoned four different ascents to it, one upon each angle, with marble steps so long that eight or ten persons may go up a-breast.

The old wall, which inclosed both the palace and the temple, is built of such monstrous blocks of stone, as exceeded all belief, and have given birth to a tradition among the natives, that the whole is the work of the Devil. There are three in particular, which lying end to end with each other, extend 183 feet in length, whereof one is 63 feet long, and the other two 60 a-piece: their depth is 12 feet, and their breadth the same; and, what adds to the wonder, these stones are raised 20 feet from the ground. The rest of the stones of this wall are of surprising dimensions, but none quite so large as these.

The long arched wall, leading to the temple, is adorned with many busts, which, for want of light, cannot be well discerned. The first object which now strikes the sight, is a spacious theatre, which is open at the other end, and presents a terrace with marble steps. This aperture leads to a square court, larger than the first; around which are magnificent buildings. On each side is a double row of pillars, which form porticoes, or galleries, of 66 fathoms in length, and eight in breadth. The bottom of this court was taken up by a third building, fronting the east, more sumptuous than the rest, and deeper; this seems to have been the body of the palace. The columns belonging to this part, are of such a size, as to be compared with those of the Hippodrome at Constantinople. Nine of these columns, (each of which is of one block), with a good piece of the entablature, are still standing.

The Corinthian order prevails throughout the whole, and the ornaments are various. The fine taste of Greece, and the magnificence of Rome, here meet; statues without number, busts of all sorts, proud trophies, curiously wrought niches, walls and ceilings enriched with bas-relief, incrustations, and other works of the finest marble; therms and caryatides, judiciously placed. Underneath the whole are vast vaults; where from time to time you discover, through the ruins, long flights of marble stairs, near two hundred in a flight. The turn and elevation of these vaults are bold and surprising: and in these subterraneous parts are many rooms, halls, rich apartments entire, and many marble tombs. The walls of these vaults are adorned with niches, bas-reliefs, and inscriptions in Roman characters; but these inscriptions are quite effaced by the length of time, and the damps; some of these vaults are quite dark, and must be visited with lights, either because of their great depth, or because the passages which may have given them light, are stopped up by rubbish; but others receive light by great windows, which stand on the level of the ground above.

All these edifices are built with stones of the enormous size already mentioned, without any visible mortar, cement, or binding whatsoever. All over and about the town, some melancholy fragment of antiquity is to be met with. The quarry, from whence they had the stone for these works, is a little way out of the town. It is cut out in steps something like an amphitheatre, where lies one stone ready hewn, which seems to surpass all that have been already described. A notion prevailed, that it was too heavy to be moved; but, upon a nice examination, it was found fastened to the rock.

Such was the city of Balbeck, and from its surprising grandeur and magnificence, we may well conclude it to have been once the most considerable place in Syria.

Obs. The study of the subterranean temple of Elephanta, and the comparison of those of Balbeck and Ebsambul, will not lose one jot in being arranged with the architectural monuments of a people of modern acquaintance to Britons, but of ancestors as laborious, as polished, and as pious as veneration for a Deity could characterise his worshippers.

21. *Ancient Monuments and Temples of Java.*

The most splendid of monuments are to be found at Prambanan, Boro Bodo, and Singa Sari. Of the first an interesting description is given by Colonel Mackenzie. Circumstances have since admitted of a more minute investigation; and our information, as far as regards their present state, is much more complete. These extensive ruins lay claim to the highest antiquity! and, considering the vicinity of the temples to have been the seat of the earliest monarchy in Java, we may be permitted, in the words of Captain Baker, to lament the contrast of the present times with "times long since past."

"Nothing (he observes), can exceed the air of melancholy, desolation, and ruin, which this spot presents; and the feelings of every visitor must be forcibly in unison with the scene of surrounding devastation, when he reflects upon the origin of this once venerated, hallowed spot; the seat and proof of the perfection of arts now no longer in existence in Java, and the type and emblem of a religion no longer acknowledged, and scarcely known among them by name. Never have I met with such stupendous, laborious, and finished specimens of human labour, and of the polished refined taste of ages long since forgot, and crowded together in so small a compass, as characterize and are manifested in this little spot; and, though I doubt not there are some remains of antiquity in other parts of the globe more worthy the eye of the traveller or the pencil of the artist, yet Chandi Sewo must ever rank with the foremost in the attractions of curiosity, or of antiquarian research."

Next to Prambanan, the ruins of Boro Bodo may be ranked as remarkable for grandeur in design, peculiarity of style, and exquisite workmanship. This temple is in the district of Boro, under the residency of the Kadu, whence, I presume, it takes its name; Bodo being either a term of contempt cast upon it by the Mahometans, or erroneously so pronounced, instead of Bud'ho; which, in its general acceptation, in the Javanese language, is synonymous with ancient, or heathen.

It is built so as to crown the upper part of a small hill, the summit terminating in a dome. The building is square, and is composed of seven terraces, rising one above the other, each of which is enclosed by stone walls; the ascent to the different terraces being by four flight of steps, leading from four principal entrances, one on each side of the square. On the top are several small latticed domes, the upper part terminating in one of a larger circumference. In separate niches, or rather temples, at equal distances, formed in the walls of the several terraces, are contained upwards of 300 stone images of devotees, in a sitting posture, and being each above three feet high. Similar images are within the domes above; and in compartments in the walls, both within and without, are carved in relief, and in the most correct and beautiful style, groupes of figures, containing historical scenes and mythological ceremonies, supposed to be representations of a principal part, either of the Ramayan or Mahabrat. The figures and costume are evidently Indian; and we are at a loss whether most to admire the extent and grandeur of the whole construction, or the beauty, richness, and correctness, of the sculpture.

Although the general design of this temple differs from those at Prambanan, a similar style of sculpture and decoration is observable; and the same may be also traced in the ruins at Singa Sari, situated in the residency of Pasaruan, where are still to be found images of Brahma, Mahadewa, Ganesa, the Bull Nandi, and others, of the most exquisite workmanship, and in a still higher degree of preservation than any remaining at Prambanan or Boro Bodo.

One of the most extraordinary monuments in this quarter, however, is an immense colossal statue of a man resting on his hams of the same character as the *porters* at Prambanan, lying on its face, and adjacent to a terrace, on which it was originally placed. This statue measures in length about 12 feet, with corrresponding dimensions in girth, cut from one solid stone.

The statue seems evidently to have fallen from the adjacent elevated terrace; although it is difficult to reconcile the probability of its having been elevated to such a station, with reference to any traces we now have of the knowledge of mechanics by the Javanese. To have raised it by dint of mere manual labour, would appear, at the present day, an Herculean task. The terrace is about 18 feet high. A second figure, of the same dimensions, has since been discovered in the vicinity of the above; and, when the forest shall be cleared, some traces of the large temple to which they formed the approach may probably be found. Not far from Singa Sari, which was once the seat of empire, and in the district of Malang, are several interesting ruins of temples, of similar construction, and of the same style of ornament.

Obs. These facts prove how far advanced were the Javanese islanders in the arts, with what hallowed respect they honoured a religion, no type or emblem of which now exists, and they are calculated to lessen our pride of modern skill, and excite our admiration of remote antiquity. If in these descriptions of ruins, the reader should be led to believe that the ancients regarded the strength of the fabric more than its elegance and symmetry, he is not far wrong; but there must have been some rules of harmony, some elegance of design, some taste of ornament in all those different countries, else the eye of the traveller could not at this distance of time trace the skilful hand of the artificer, and the sublime genius of the designer, in the stupendous ruins of far more stupendous structures. And we know of no article better calculated to harmonize with those that have gone before, than the following account of the

22. *Architectural Antiquities of Arabia Petræa.*

Mr. Bankes, who has visited some of the most celebrated scenes in Arabia, in company with several other English travellers, left Jerusalem for Hebron, where they viewed the mosque erected over the tomb of Abraham; an edifice constructed in the lower part of such enormous masses of stone, many upwards of 20 feet in length, that it must be ascribed to that remote age, in which durability was the end chiefly consulted in the formation of all edifices of the monumental kind.

They then proceeded to Karrac, through a country broken into hills and pinnacles of the most fantastic form, and along the foot of mountains where fragments of rock-salt indicated the natural origin of that intense brine, which composes the waters of the Dead Sea.

Karrac is a fortress situated on the top of a hill. The entrance is formed by a winding passage, cut through the solid rock. In the vicinity, they saw several sepulchres hollowed out of the rock; and found the inhabitants of the place a mingled race of Mahometans and Christians, remarkably hospitable, and living together in terms of freer intercourse than at Jerusalem.

After leaving Karrack, they sojourned for a short time with a party of Bedoueen Arabs; and, after quitting their tents, they passed into the valley of Ellasar, where they noticed some relics of antiquity, which were conjectured to be of Roman origin. Here again, they rested with a tribe of Arabs. The next day they pursued their journey, partly over a road paved with lava, and which, by its appearance, was evidently a Roman work. The travellers stopped that evening at Shubac, a fortress in a commanding situation, but incapable, by decay, of any effectual defence.

In the neighbourhood of this place, they encountered some difficulties from the Arabs, but proceeded unmolested till they reached the tents of a chieftain called Eben Raschib, who took them under his protection. This encampment was situated on the edge of a precipice, from which they had a magnificent view of Mount Gebel Nebe-Haroun, the hill of the prophet Aaron, (Mount Hor:) and a distant prospect of Gebel-Tour (Mount Sinai), was also pointed out to them. In the fore-ground, on the plain below, they saw the tents of the hostile Arabs, who were determined to oppose their passage to Wadi Moosa, the ruins of which were also in sight.

After some altercation, the travellers were permitted to pass; and having crossed a clear and beautiful stream, they entered on the wonders of *Wadi Moosa*; or the *Valley of Moses*.

The first object that attracted their attention, was a mausoleum, at the entrance of which stood two colossal animals, but whether lions or sphinxes they could not ascertain, as they were much defaced and mutilated. They then, advancing towards the principal ruins, entered a narrow pass, varying from fifteen to twenty feet in width, overhung by precipices, which rose to the general height of two hundred, sometimes reaching five hundred, feet, and darkening the path by their projecting ledges. In some places, niches were sculptured in the sides of this stupendous gallery, and here and there rude masses stood forward, that bore a remote and mysterious resemblance to the figures of living things, but over which, time and oblivion had drawn an inscrutable and everlasting veil. About a mile within this pass, they rode under an arch, perhaps that of an aqueduct, which connected the two sides together; and they noticed several earthen pipes, which had formerly distributed water.

Having continued to explore the gloomy windings of this awful corridor for about two miles, the front of a superb temple burst on their view. A statue of Victory, with wings, filled the centre of an aperture in the upper part, and groups of colossal figures, representing a centaur, and a young man, stood on each side of the lofty portico.

This magnificent structure is entirely excavated from the solid rock, and preserved from the ravages of the weather by projections of the overhanging precipices. About three hundred yards beyond this temple they met with other astonishing excavations; and, on reaching the termination of the rock on their left, they found an amphitheatre, which had also been excavated, with the exception of the proscenium: and this had fallen into ruins. On all sides the rocks were hollowed into innumerable chambers and sepulchres; and a silent waste of desolated palaces, and the remains of constructed edifices, filled the area to which the pass led.

These ruins, which have acquired the name of Wadi Moosa, from that of a village in their vicinity, are the wreck of the city of Petræa, which, in the time of Augustus Cæsar, was the residence of a monarch, and the capital of Arabia Petræa. The country was conquered by Trajan, and annexed by him to the province of Palestine. In more recent times, Baldwin I. king of Jerusalem, having made himself also master of Petræa, gave it the name of the Royal Mountain.

The travellers having gratified their wonder with the view of these stupendous works, went forward to Mount Hor, which they ascended, and viewed a building on the top containing the tomb of Aaron; a simple stone monument, which an aged Arab shows to the pilgrims. Having remained in this spot, consecrated by such great antiquity, they returned next morning, and again explored other portions of the ruins of Petræa; after which they went back to Karrac. They then turned their attention to other undescribed ruins, of which they had received some account from the Arabs;

and, finally, proceeded to view those of Jerrasch, which greatly exceed in magnitude and beauty those of Palmyra.

A grand colonnade runs from the eastern to the western gates of the city, formed on both sides of marble columns of the Corinthian order, and terminating in a semi-circle of sixty pillars of the Ionic order, and crossed by another colonnade running north and south.

At the western extremity stands a theatre, of which the proscenium remains so entire, that it may be described as almost in a state of undecayed beauty. Two superb amphitheatres of marble, three glorious temples, and the ruins of gorgeous palaces, with fragments of sculpture and inscriptions, mingled together, form an aggregate of ancient elegance, which surpasses all that popery has spared of the former grandeur of Rome.

Obs. There is something so sublime in the thought that, among the ancient monuments of architecture which we meet with, as described by travellers or alluded to by historians, by far the greater part have been once dedicated to the service of religion. In the instances we have already produced, these have been sumptuous fabrics, evincing grace, regularity, and beauty, but we shall now offer others in which, though design be manifest, science was wanting to add elegance to convenience, and taste to grandeur.

23. *Stone-henge.*

This celebrated monument of antiquity is of very uncertain date. Its situation is on Salisbury-plain, six miles from the city of that name.

It is composed of a number of large unwrought stones, some standing in a perpendicular position whilst others are laid over them horizontally, that is, one stone is laid horizontally over two perpendicular ones. The whole work is of a circular form, and is a 110 feet in diameter, without a roof. It was anciently environed with a deep trench, still appearing about thirty feet wide: so that betwixt it and the work itself, a large space of ground is left.

It had from the plain three open entrances, (the most conspicuous of which lies north-east;) at each of which were raised, on the outside of the trench, two huge stones, gate-wise, parallel of less proportion.

The inner part of the work, consisting of an hexagonal figure, was raised, upon the basis of four equilateral triangles, which formed the whole structure. The inner part was double, having within it also another hexagon raised. All within the trench is situated upon commanding ground on a foundation of hard chalk, and much higher than the surrounding plain; in the innermost part of the work is a stone, not much above the surface of the earth, lying towards the east, (four feet wide, and sixteen feet long,) which is supposed to have been an altar.

The great stones at the entrances from the outside of the trench, are seven feet wide, three feet thick, and twenty feet high. The parallel stones on the inside of the trench are four feet wide, and three feet thick; but they are so broken, that their proportions cannot be exactly measured. The stones which make the outward circle are seven feet wide, three feet and a half thick, and fifteen feet and a half high; each stone having two tenons mortised into the architrave, throughout the whole circumference. The architraves are jointed exactly in the middle of each of the perpendicular stones, that their weight might have an equal bearing. The smaller stones of the inner circle are one foot and a half wide, one foot thick, and six feet high. These had no architrave upon them, but were raised perpendicular, of a pyramidal form. The stones of the greater hexagon are seven feet and a half wide, three feet and three quarters thick, and twenty feet high, each stone having one tenon in the middle. The stones of the inner hexagon are two feet and a half wide, one foot and a half thick, and eight feet high, in form, pyramidal, like those of the inner circle. The architrave lying round about, upon the perpendicular stones of the outward circle is three feet and a half wide, and two feet and a half high. The architrave on the top of the great stones of the outward hexagon, is sixteen feet long, three feet and three quarters wide, and three feet and a quarter high.

Dr. Stukely computes the number of stones in the following manner: "the great oval consists of ten uprights; the inner with the altar of twenty; the great circle of thirty; the inner of forty; which are 100 upwright stones; five imposts of the great oval; thirty of the great circle; the two stones on the bank of the area, the stone lying within its entrance, and that standing without; and another on the ground directly opposite to the entrance of the avenue; so that the whole number is 140." This singular structure is universally believed to be the remains of some magnificent Druidical Temple.

Obs. Next to their temples, the ancients seem to have bestowed most labour on the tombs of their dead. Men of the present day do little more than indicate their existence, if we may judge of the time spent in prosecuting the improvement of the fine arts. The ancients still live either by their architectural monuments, or the application of those sciences which can only become extinct with the annihilation of our species. They speak to us even from their tombs; and in our selection of these relicts, we shall first present the reader with a description of some

24. *Celtic Tombs.*

Some workmen being employed in 1819 to level three ancient Tumuli called *Chronicle-hills*, for the improvement of the land of Got-moor near Whittlesford, the following interesting discoveries were made.

The middle tumulus was found to be eight feet high, and 27 yards in diameter; the others were not so large. They ranged along an ancient wall, constructed of flint and pebbles.

Its length was four rods; its thickness thirty inches, and it had three abutments upon its eastern side. Beyond this wall, at the distance of twelve rods to the east, was found an ancient well, made with clunch, nine feet in diameter, full of flints and tiles of a curious shape, so formed as to lap over each other. Some of these tiles had a hole in the centre; and, from their general appearance, it was believed that they had been used in an aqueduct. In this well were found two bucks' or elks' horns, of very large size. Upon opening the *tumuli*, the workmen removed, from the larger one, four human skeletons, which were found lying upon their backs, about two feet from the bottom. Some broken pieces of *terra cotta*, with red and with black glazing, were found on opening the *tumuli*, heaped among the earth, which, from the nature of the workmanship, seemed to be Roman; but this is uncertain.

In opening the northern *tumulus*, and in removing the wall upon its eastern side, such an innumerable quantity of the bones of a small quadruped was found, that they were actually stratified to the depth of four inches,—the same were also found near other sepulchres, about a hundred yards to the north of *the Chronicle Hills.*

The most singular circumstance is, that there is no living animal now in the country to which these bones, thus deposited by millions, may be anatomically referred. The bones of the jaw correspond with those of the castor, or beaver, as found in a fossil state in the bogs near Chatteris; but the first are incomparably smaller. Like those of the beaver, they are furnished with two upper and two lower incisors, and with four grinders on each side. They are supposed, however, to have belonged to the Lemming, which sometimes descends in moving myriads from the mountains of Lapland.

About 100 yards from the north of *the Chronicle Hills*, there were found two other sepulchres, in which human skeletons were found in *soroi*, constructed of flints and pebbles, put together with fine gravel. These *soroi* were surrounded each by a circular wall two and a-half feet thick, and about three feet high, and twenty-two feet in diameter.

The whole were covered beneath mounds of earth, which rose in hills about two feet above the *soros*, having been probably diminished in height by long pressure, and the effect of rains.—In the first *soros* (which was five feet square, and eight feet deep, brought to a point with pebbles,) were found two skeletons. The uppermost appeared to be of larger size. Under the skull was found the blade of a poignard or knife. The head of this skeleton rested upon the body of the other. The *soros* was full of dirt; and patches of a white unctuous substance, like spermaceti, adhered to the flints. It had an oak bottom, black as ink, but stained with the green oxide of copper, owing to the decomposition of an ancient bronze vessel; the composition consisting, as usual, in ancient bronze, of an alloy of copper and tin, in the proportion of eighty-eight of the former to twelve of the latter. Large iron nails, reduced almost to an oxide, were also found here. In the other *soros* (which was four feet square within its circular wall, and eight feet deep,) a human skeleton was found; and another below it in a sitting posture, with an erect spear, the point of which was of iron. Nails were found here, but no wood, as in the other *soros*. Here the small quadruped bones were also found in great abundance. The mode of burial exhibited by those ancient sepulchres, added to the fact of the bronze reliques found within one of them, and also that no Roman coins have ever been discovered among the other ruins, plead strongly for the superior antiquity of the people here interred; and lead to a conclusion, that *the Chronicle Hills* were Celtic tombs.

Obs. It is not that we would say these Celtic tombs are more ancient than those of Egypt; their recent discovery serves to recommend them to us; the same may give them interest to the reader. But let us not be accused of partiality; take the following description of the

25. *Tumuli scattered among the Pyramids of Egypt.*

M. Caviglia and Mr. Salt have explored the contents of several of the Tumuli, which when viewed from the top of the great Pyramid, appear in countless numbers scattered among the Pyramids, extending on the left bank of the Nile, north and south, as far as the eye can reach. They have been mentioned by travellers, but never examined before with the attention they merit.

The stone buildings to which they gained access, by freeing them from the sand and rubbish with which they were choked, are generally oblong, with their walls slightly inward from the perpendicular,—flat-roofed, with a parapet rounded at top, and rising about a foot above the terrace. Their walls are constructed of large masses, made nearly to fit with each other, though rarely rectangular. Some have door-ways, ornamented above with a volute, covered with hieroglyphics; others only of square apertures, gradually narrowing inward. The doors and windows are all on the north sides; perhaps because least exposed to the wind-carried sands from the Libyan desert.

The inside of the walls of the first that was examined was stuccoed, and embellished with rude paintings; one of which represented the Sacred Boat, another a Procession: and in the southern extremity were found several mouldering mummies, laid one over the other, in a recumbent position. Many of the bones were entire; and on one skull was part of its cloth covering, inscribed with hieroglyphics. The second which he examined had no paintings, but contained several fragments of statues; two of which composed the entire body of a walking figure, almost the size of life, with the arms hanging down and resting on the thighs. Mr. Salt thinks this was intended as a portrait, the several parts of which were marked with strict attention to nature, and coloured after life, having glass eyes or transparent stones to improve the resemblance. A head was also discovered which Mr. Salt describes as a respectable specimen of art. Many of the fragments of granite and alabaster sculptures give a higher idea of Egyptian art than has usually prevailed; much attention being shewn to the marking of the joints and muscles.

In another of these buildings was a sculptured boat of a large size, with a square sail, different from any now in use on the Nile. In the first chamber were bas-reliefs of men, deer, and birds, painted to resemble nature: the men engaged in different mechanical occupations. In the second apartment there were similar productions;—a quarrel between some boatmen, executed with great spirit; men engaged in agricultural pursuits, ploughing, hoeing, stowing the corn in magazines, &c. vases painted in vivid colours; musicians with a group of dancing women. Another chamber was without embellishment; a fourth had figures and hieroglyphics; and in a fifth were hieroglyphics executed on white plaster, as it would appear, by means of stamps.

In all the mausoleums which were opened, fragments of mummy cloth, bitumen, and human bones, were found; but, what is, perhaps, most singular of all, in one apartment or other of all of them was a deep shaft or well. One that was cleared out by M. Caviglia was 60 feet deep; and, in a subterraneous chamber a little to the south, at the bottom of the well, was found, without a lid, a plain but highly finished sarcophagus; and from this it may be inferred that in each mausoleum, such a chamber and sarcophagus may be found, at the bottom of the well.

Mr. Salt mentions that all the mausoleums consisted of different apartments, some more, some less, in number; variously disposed and similarly decorated; and that the objects in which the artists have best succeeded are animals and birds: the human figures are in general out of proportion; but the action in which they are engaged is intelligibly, and in some instances energetically expressed. In many of the chambers the colours retain all their original freshness. The bas-reliefs and colouring after nature, in these early efforts of art, serve, he says, to embody the forms, and to present a species of reality that mere painting can with difficulty produce.

Obs. The mausoleums in which the ancients buried their dead were not more carefully and compactly constructed than their coffins or sarcophagi, as is proved by the following account of one of these relicts found at Bushire.

26. *Stone Sarcophagus found at Bushire.*

A stone sarcophagus was forwarded to the Asiatic Society in 1818, which was dug out of the foundation of some ancient ruins, about eight miles from Bushire. It contained, when discovered, the disjointed bones of a human skeleton, perfect in their shape, but they broke down in a short time after their exposure to the atmosphere.

The vessel is of calcareous sand-stone, the lid of a micaceous rock, and it was fastened down by metallic pins. This is the second of the kind which has been discovered. Those which are usually dug up, are of baked clay, and it is concluded, that these rarer kind contain the remains of eminent personages.

Obs. But of all the tombs of antiquity, those of the Kings of Egypt were by far the grandest; and, whatever may be the obligations we owe former travellers for a knowledge of these relics, the following account cannot fail to be read with pleasure and profit.

27. *Tombs of the Egyptian Kings.*

M. Belzoni, who is now in Egypt, in the act of exploring that celebrated country, for the remains of the ancient temples, &c. which once adorned it, has transmitted the following account of his discovery of the Egyptian tombs, to his friend M. Viscomti at Paris, dated Cairo, *Jan.* 9*th*, 1818.

On returning to Thebes, I applied myself once more o discover what has been, from time immemorial, the object of discovery for all travellers of every nation, I mean the tombs of the Kings of Egypt.

It is known that, independent of those tombs which are open, there existed several under ground, but no person has yet discovered in what place. By means of observations on the situation of Thebes, I at length found the index that should lead me on the way. After various excavations, I succeeded in discovering six of these tombs in the valley of BIBAU EL MOLUCK, one of which is that of Apis, as it seems to be pointed out by the mummy of an ox found there. This mummy is filled with asphaltes. For the rest, nothing that I can say would enable you to conceive the grandeur and magnificence of this tomb.

This is undoubtedly the most curious and the most astonishing thing in Egypt, and which gives the highest idea of the labours of its ancient inhabitants. The interior, from one extremity to the other, is 309 feet; it is cut out of the solid pure-white rock, and contains a great number of chambers and corridors. The walls are entirely covered with hieroglyphics and bas-reliefs, painted in fresco. The colours are of a brightness to which nothing, within our knowledge, is to be compared; and are so well preserved, that they appear to have been just laid on. The colours are *vermillion ochres*, and *Indigo*, but not gaudy, owing to the judicious management of the Blacks.

But the most beautiful antiquity of this place, in the principal chamber, is a sarcophagus of a single piece of alabaster, nine feet seven inches long, by three feet nine inches wide, within and without equally covered with hieroglyphics and carved figures in *Intaglio*. This large vessel has the sound of a silver bell, and the transparency of glass. There can be no doubt that, when I shall have transported it to England, as I hope to do, it will be esteemed one of the most precious articles in our European Museums.

It is a curious fact, that in one of the Theban tombs two statues of wood, a little larger than life, were found as perfect as if newly carved, excepting in the sockets of the eyes, which had been of metal, probably copper.

28. *Excavation of Cephrenes; the second Pyramid of Ghizas.*

The following account of M. Belzoni's Herculean labours in opening this celebrated remnant of antiquity, is given in his own words.

"Having acquired permission, I began my labours on the 10th of February, 1818, at a point on the north side in a vertical section at right angles to that side of the base. I saw many reasons against my beginning there, but certain indications told me that there was an entrance at that spot. I employed sixty labouring men, and began to cut through the mass of stones and cement which had fallen from the upper part of the pyramid, but was so hard joined together, that the men spoiled several of their hatchets in the operation: the stones which had fallen down along with the cement having formed themselves into one solid and almost impenetrable mass. I succeeded, however, in making an opening of fifteen feet wide, and continued working downwards in uncovering the face of the pyramid; this work took up several days, without the least prospect of meeting with any thing interesting. Meanwhile, I began to fear that some of the Europeans residing at Cairo might pay a visit to the pyramids, which they do very often, and thus discover my retreat, and interrupt my proceedings.

On the 17th of the same month we had made a considerable advance downwards, when an Arab workman called out, making a great noise, and saying that he had found the entrance. He had discovered a hole in the pyramid into which he could just thrust his arm and a djerid of six feet long. Towards the evening we discovered a larger aperture, about three feet square, which had been closed in irregularly, by a hewn stone; this stone I caused to be removed, and then came to an opening larger than the preceding, but filled up with loose stones and sand. This satisfied me that it was not the real but a forced passage, which I found to lead inwards and towards the south; the next day we succeeded in entering fifteen feet from the outside, when we reached a place where the sand and stones began to fall from above. I caused the rubbish to be taken out, but it still continued to fall in great quantities; at last, after some days labour, I discovered an upper forced entrance, communicating with the outside from above, and which had evidently been cut by some one who was in search of the true passage. Having cleared this passage, I perceived another opening below, which apparently ran towards the centre of the pyramid. In a few hours I was able to enter this passage, and found it to be a continuation of the lower forced passage, which runs horizontally towards the centre of the pyramid, nearly all choked up with stones and sand. These obstructions I caused to be taken out; and, at half-way from the entrance, I found a descent, which also had been forced, and which ended at the distance of forty feet. I afterwards continued the work in the horizontal passage above, in hopes that it might lead to the centre; but I was disappointed, and at last was convinced that it ended there, and that to attempt to advance in that way would only incur the risk of sacrificing some of my workmen, as it was really astonishing to see how the stones hung suspended over their heads, resting, perhaps, by a single point. Indeed, one of these stones did fall, and had nearly killed one of the men. I, therefore, retired from the forced passage, with great regret and disappointment.

Notwithstanding the discouragements I met with, I recommenced my researches on the following day, depending upon my indications. I directed the ground to be cleared away to the eastward of the false entrance; the stones incrusted and bound together with cement, were equally hard as the former, and we had as many large stones to remove as before. By this time my retreat had been discovered, which occasioned me many interruptions from visitors, among others was the Abbé de Forbin.

On February 28, we discovered a block of granite in an inclined direction towards the centre of the pyramid, and I perceived that the inclination was the same as that of the passage of the first pyramid, or that of Cheops; consequently, I began to hope that I was near the true entrance. On the 1st of March we observed three large blocks of stone one upon the other, all inclined towards the centre: these large stones we had to remove, as well as others much larger as we advanced, which considerably retarded our approach to the desired spot. I perceived, however, that I was near the true entrance, and, in fact, the next day, about noon, on the 2d of March, was the epoch at which the grand pyramid of Cephrenes was at last opened, after being closed up for so many centuries, that it remained an uncertainty whether any interior chambers did or did not exist. The passage I discovered was a square opening of four feet high and three and a half wide, formed by four blocks of granite, and continued slanting downward at the same inclination as that of the pyramid of Cheops, which is an angle of twenty-six degrees. It runs to the length of 104 feet five inches, lined the whole way with granite. I had much to do to remove and draw up the stones which filled the passage down to the portcullis or door of granite, which is fitted into a niche almost made of granite. I found this door supported by small stones within eight inches of the floor, and, in consequence of the narrowness of the place, it took up the whole of that day and part of the next to raise it sufficiently to afford an entrance; this door is one foot three inches thick, and, together with the work of the niche, occupies six feet eleven inches, where the granite work ends; then commences a short passage, gradually ascending towards the centre, twenty-two feet seven inches, at the end of which is a perpendicular of fifteen feet; and the left is a small forced passage cut in the rock; and also above, on the right, is another forced passage, which runs upwards and turns to the north thirty feet, just over the portcullis. There is no doubt that this passage was made by the same persons who forced the other, in order to ascertain if there were any others which might ascend above, in conformity to that of the pyramid of Cheops. I descended the perpendicular by means of a rope, and found a large quantity of stones and earth accumulated beneath, which very nearly filled up the entrance into the passage below, which inclines towards the north. I next proceeded towards the channel that leads to the centre, and soon reached the horizontal passage. This passage is five feet eleven inches high, three feet six inches wide, and the whole length, from the above-mentioned perpendicular to the great chamber, is 158 feet eight inches. These passages are partly cut out of the living rock, and at half way there is some mason's work, probably to fill up some vacancy in the rock: the walls of this passage are in several parts covered with incrustations of salts.

On entering the great chamber, I found it to be forty-six feet three inches long, sixteen feet three inches wide, and 23 feet six inches high; for the most part cut out of the rock, except that part of the roof towards the western end. In the midst we observed a sarcophagus of granite, partly buried in the ground, to the level of the floor, eight feet long, three feet six inches wide, and two feet three inches deep inside, surrounded by large blocks of granite, being placed apparently to guard it from being taken away, which could not be effected without great labour; the lid of it had been opened; I found in it only a few bones of a human skeleton, which merit preservation as curious reliques, they being, in all probability, those of Cephrenes, the reported builder of the pyramid. On the wall of the western side of the chamber is an Arabic inscription, a translation of which has been sent to the British Museum. It testifies that 'this pyramid' was opened by the masters Mahomet El Aghari and Otman, and that it was inspected in presence of the Sultan Ali Mahomet the 1st. Ugloch. There are also several other inscriptions on the walls, supposed to be Coptic (qu. Enchorial?) Part of the floor of this chamber had been removed in different places, evidently in search of treasure, by some of those who had found their way into it. Under one of the stones I found a piece of metal, something like the thick part of an axe, but it is so rusty and decayed, that it is almost impossible to form a just idea of its form. High up and near the centre, there are two small square holes, one on the north and the other on the south, each one foot square; they enter into the wall like those in the great chamber of the first pyramid. I returned to the before-mentioned perpendicular, and found a passage to the north in the same inclination of twenty-six degrees as that above: this descends forty-eight feet six inches, where the horizontal passage commences, which keeps the same direction north fifty-five feet, and half-way along it there is on the east a recess of eleven feet deep. On the west side there is a passage twenty feet long, which descends into a chamber thirty-two feet long and nine feet nine inches wide, eight and six feet high; this chamber contains a quantity of small square blocks of stone, and some unknown inscriptions written on its walls. Returning to the original passage, and advancing north, near the end of it is a niche to receive a portcullis like that above. Fragments of granite, of which it was made, are lying near the spot. Advancing still to the north I entered a passage which runs in the same inclination as that before mentioned, and at forty-seven feet six inches from the niche it is filled up with some large blocks of stone, put there to close the entrance which issues out precisely at the base of the pyramid. —According to the measurements, it is to be observed that all the works below the base are cut into the living rock, as well as part of the passages and chambers before mentioned. Before I conclude, I have to mention that I caused a range of steps to be built, from the upper part of the perpendicular to the passage below, for the accommodation of visitors.

It may be mentioned, that, at the time I excavated on the north side of the pyramid, I caused the ground to be removed to the eastward between the pyramid and the remaining portico, which lies nearly in a line with the pyramid and the sphynx. I opened the ground in several places, and, in particular, at the base of the pyramid; and in a few days I came to the foundation and walls of an extensive temple, which stood before the pyramid at the distance of only forty feet. The whole of this space is covered with a fine platform which no doubt runs all round the pyramid. The pavement of this temple, where I uncovered it, consists of fine blocks of calcareous stone, some of which are beautifully cut and in fine preservation; the blocks of stone that form the foundation are of an immense size. I measured one of twenty-one feet long, ten feet high, and eight in breadth (120 tons weight each) there are some others above ground in the porticoes, which measured twenty-four feet in length, but not so broad nor so thick.

Obs The following description is calculated to suggest many curious inquiries, which even the greatest researches into the relicts of the "olden times" can hardly be said to gratify; but without it, the article that went before would have been incomplete.

29. *Andro Sphynx in front of the Pyramid of Cephrenes.*

One of the most brilliant of M. Caviglia's labours was that of uncovering the great Andro-Sphynx in front of the pyramid Cephrenes. The labour was immense; it cost him three months incessant exertion, with the assistance of from sixty to one hundred persons every day, to lay open the whole figure to its bases and expose a clear area, extending one hundred feet from its front;—a labour on which they were greatly impeded by the moveable nature of the sand, which by the slightest wind or concussion, was apt to run down like a cascade of water, and fill up the excavation; this colossal figure is cut out of the rock; the paws, and some projecting lines, where perhaps the rock was deficient, or which may have been repaired since its first construction, being composed of masonry.

On the stone platform in front, and centrally between the paws of the sphynx; which stretch out fifty feet in advance of the body, was found a large block of granite, two feet thick, fourteen high, and seven broad. It fronts the east, as does the face of the sphynx, is highly embellished with sculptures in bas reliefs representing two sphynxes on pedestals; and priests presenting offerings, with a well executed hieroglyphical inscription beneath: the whole covered at top, and protected as it were with the sacred globe, the serpent, and the wings.

Two other tablets of calcareous stone, similarly ornamented, were conjectured, with the former, to have constituted part of a temple, by being placed one on each side of the latter at right angles to it. One of them was in its place, the other thrown down and broken.

A small lion *couchant*, with its eyes directed towards the sphynx, was in front of this edifice. Several fragments of other lions and the fore part of a sphynx were likewise found; all of which, as well as the sphynx, the tablets, walls, and platforms on which the little temple stood, were covered with red paint, which would seem here as in India, to have been appropriated to sacred purposes; perhaps as being the colour of fire. A granite altar stands in front of the temple, one of the four horns being still in its place, and the effects of fire visible on the top of the altar.

On the side of the paw of the great sphynx, and on the digits of the paws, are Greek inscriptions; as also on some small edifices in front of the sphynx, inscribed to the sphynx, to Harpocrates, Mars, Hermes, to Claudius, (on an erasure, in which can be traced a former name, that of Nero) to Septimius Severus, (over an erasure of Geta, &c.)

Obs. A fact disclosed in the first paragraph of the following article has induced us to give it a place here. They who cannot travel to Egypt to behold a pyramid, may be able to wend their way to Great Russell-street, Bloomsbury, and if our remarks give them a greater zest for the treasures of the

British Museum, the labour of this article will have been amply rewarded.

30. *Colossal Busts of Memnon and Orus.*

1. In M. Belzoni's first journey into Nubia in search of antiquities, he succeeded in removing to Alexandria the head known by the name of the Memnon's head, a colossal bust ten feet in height, formed out of a single block of granite, and about twelve tons in weight. This head, which the French were unable to remove even after blowing off with gunpowder a portion of the back part, M. Belzoni, by the assistance solely of the native peasantry, without the aid of any machine, succeeded in removing from Thebes to Alexandria.

The chief difficulty lay in transporting it from Thebes to the Nile, to get it on board a vessel for Alexandria, This labour required a degree of patience and perseverance which few men possess: it took him six months, though the distance to the Nile was only about two miles. This colossal bust, which reached England in 1817, has been placed on a pedestal, in the Egyptian room of the British Museum.

This Colossus has frequently been mistaken for the statue of Osymandyas. Strabo asserts that it was named Ismandès. These words were derived from Os Smandi, to give out a sound; a property possessed, it was said, by this statute, at the dawn of day and at sun-set. Its true name was Amenophes.

This name was derived from *amenoupki*, to give good tidings, because at the vernal equinox, so highly valued by the Egyptians, the statue was reported to pronounce the seven vowels which compose the terrestrial music, the image of the seven planets, the harmonious flow of which had received from the priests the name of the celestial music.

Some suppose that mechanism, ingeniously contrived by the priests, was the sole probable cause of this miracle, which ceased in the fourth century of the Christian era. At Megara, a particular stone also gave out sounds when it was struck by an instrument of iron.

2. The Colossus of Orus. M. Belzoni's sagacity and perseverance have enabled him to oblige the world with an account of another Colossus, of a still greater size than that just mentioned: it is that of Orus. In a letter to a friend at Paris, M. Belzoni says:

"It was not until my second journey, in 1817, that I discovered the head of a colossus much greater than that of Memnon. This head of granite, and of a single block, is by itself ten feet from the neck to the top of the mitre, with which it was crowned. Nothing can be in better preservation. The polish is still as beautiful as if it had just come from the hands of the statuary."

He carried with him to Cairo one of the arms belonging to this statue. As he succeeded so well in removing the Memnon, may we not hope that he will be encouraged also to attempt the removal of this head, and that we may ere long see it placed beside its colossal brother in the British Museum?

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Obs. Of the walls of Babylon 318 feet high and 81 feet thick; we might, indeed, entertain a doubt, had we not such proofs of the extraordinary genius and industry of the ancients in the descriptions we have given of the pyramids and temples of Egypt; but it will not appear incredible, if the following account of the great wall of China be not exaggerated.

31. *The great Wall of China.*

This wall is conducted over the summits of high mountains, some of which are 5225 feet high; across the deepest vales; over wide rivers by means of arches; and in many parts is doubled and trebled, to command important passes. At the distance of almost every hundred yards is a tower or massive bastion. Its extent is supposed to be 1500 miles; but in parts of less danger it is not equally strong. And towards the N.W. it is only a rampart of earth.

Near Koopekoo, this amazing fortification is 25 feet in height, and at the top about 15 feet thick, and it extends

1200 miles: some of the towers, which are square, are 48 feet high, and about 40 feet wide. The stone used in the foundations, angles, &c. is strong grey granite; but the greater part is composed of blueish bricks. The mortar is remarkably pure and white. Sir George Staunton asserts that it has existed for 2000 years. Du Holde informs us that "this prodigious work was constructed 215 years before the birth of Christ, by the orders of the first Emperor of the family of Tsin, to protect three large provinces from the irruptions of the Tartars." Mr. Bell, who resided for some time in China, assures us that this wall was built about the year 1160, by one of the Emperors, to prevent the frequent incursions of the Monguls, whose cavalry used to ravage the provinces, and escape before an army could be assembled to oppose them. Renaudot observes that no ancient Oriental Geographer mentions this wall. It is also surprising that Marco Paulo, who resided long in the north of China and in the country of the Monguls, should have remained ignorant of so stupendous a work. However, we may conclude that similar modes of defence have been adopted in different ages: perhaps, too, the ancient barrier may have fallen into decay, and may have been replaced by the present extensive and useful structure.—As it stands, there is no other building in the world so truly defensive, magnificent, or extensive.

Obs. The introduction of this description of the great Wall of China, serves as a barrier between the dead and the living monuments of antiquity, and structures of recent times. When we want to compare objects, we place them side by side; when we desire to contemplate them alone, the more solitary we can place ourselves, the more insulated we can find them, the more likely are we to arrive at results more certain, and knowledge more sure than are derived from snatching hasty glances in the throng, and gleaning information where the bustle of the world distracts, and the clamours of the importunate divide our attention. With this impression we now leave the spectator alone beside the

32. *Pagoda of Seringham.*

This Pagoda is the most famed in all Hindostan for its sanctity, magnitude, and the vast resort of Pilgrims, who go to it from all quarters. The following description of it is given by Mr. Orme. "It is composed of seven square inclosures, one within the other; the walls of which are 20 feet high, and four thick. These enclosures are 350 feet distant from each other, and each has four large gates with a high tower, which are placed, one in the middle of each side of the enclosure, and opposite to the four cardinal points. The outward wall is near four miles in circumference, and its gateway to the south is ornamented with pillars, several of which are single stones 35 feet long, and nearly five in diameter; and those which form the roof are still larger. In the inmost enclosures are the chapels. About half a mile to the east of Seringham, and nearer to the Cavery than the Coleroon, is another large pagoda called Jumbakistna, but this has only one enclosure. The extreme veneration in which Seringham is held, arises from a belief that it contains the identical image of the god Wistchnu, which used to be worshipped by the god Brachma.

Pilgrims from all parts of the peninsula come here to obtain absolution, and none come without an offering of money; and a large part of the revenue of the island is allotted for the maintenance of the Brahmins who inhabit the pagoda; and these with their families formerly composed a multitude of not less than 40,000 souls, maintained without labour by the liberality of superstition. There, as in all other great pagodas of India, the Brahmins live in a subordination which knows no resistance, and slumber in a voluptuousness which knows no wants; and sensible of the happiness of their condition, they quit not the silence of their retreats to mingle in the tumults of the state, nor point the sword flaming from the altar, against the authority of the sovereign, or the tranquillity of the government.

Obs. Some men have laboured to perpetuate their names and fame in one way, others in other ways. The names of the sovereigns who reared the pyramids, and of those who constructed the great wall of China, may all be forgotten like those of the pious druidical priests who superintended the rude erection at Stone Henge. And though Louis XIV.

expended, perhaps, as much money in building Versailles as would have reared a pyramid, the Roman emperors have left monuments of little expense but of great durability to perpetuate their name. Of this kind is the Arch of Trajan at Benevento, in Italy.

33. *The Arch of Trajan.*

The arch of Trajan now called the *Portacturea*, forms one of the entrances to the city of Benevento, in Italy. This arch, though it appears to great disadvantage from the walls and houses that hem it in on both sides, is in tolerable preservation, and one of the most magnificent remains of Roman grandeur to be met with out of Rome. The architecture and sculpture are both singularly beautiful.

This elegant monument was erected in the year of Christ 114, about the commencement of the Parthian war, and after the submission of Decebalus had entitled Trajan to the surname of Dacius. The order is Composite; the materials, white marble; the height 60 palms; length 37 and a half; and depth 24. It consists of a single arch, the span of which is 20 palms, the height 35. On each side of it, two fluted columns, upon a joint pedestal, supporting an entablature and an attic. The intercolumniations and frieze are covered with basso-relievos, representing the battles and triumphs of the Dacian war. In the attic is the inscription. As the sixth year of Trajan's consulate, marked on this arch, is also to be seen on all the miliary columns he erected along his new road to Brundusium, it is probable that the arch was built to commemorate so beneficial an undertaking.

Obs. People who live in London, or in any of the great towns of the United Kingdom, that are regularly and scientifically supplied with water, reflect little on the great cost to which the ancients went to construct aqueducts; a species of canals to which their ignorance of the principles of hydrostatics and hydraulics reduced them. The invention of pumps is very ancient, but the knowledge of the fact that fluids, by their pressure, may be conveyed over hills and vallies, in bended pipes, to any height not greater than the level of the springs from whence they flow, left the ancients to construct such vast aqueducts as the following.

34. *The Aqueduct and Bridge of Alcantara near Lisbon.*

The situation of Lisbon, on the assemblage of hard and calcareous hills, precludes the advantage possessed by other capital cities, of a ready supply of water. There are some wells, however, but the water is of a very indifferent quality, and unfit for domestic purposes.

In the year 1511, the first idea of supplying the capital with water was suggested by Emanuel the Great, King of Portugal. It was proposed by his architect, Francisco de Olhando, that some neighbouring springs should be conducted to a magnificent fountain, to be erected in the Praca do Rocio, in which a column surmounted by an allegorical figure of the city of Lisbon, was guarded at the base by four elephants spouting water into a marble basin; but the scheme was unaccountably abandoned. The next attempt was made by the Infante Don Luis, but with as little success.

According to Luis Marinho, a sum of 600,000 crusadoes was raised by public subscription to defray the expense; but the money was foolishly lavished in honour of the entry of Philip III. of Spain, into Lisbon. Five successive sovereigns passed over, until the year 1713, when the foundation stone of the present aqueduct was laid under the auspices of John V. by a Neapolitan, named Canavarro, who died during the progress of the work. He was then succeeded by Brigadier Mansel de Maya, who finished it August 6th, 1732; others say 1738; since which it has remained, notwithstanding the dreadful earthquake of 1755, an unshaken monument of stability and grandeur, to the contemplation of present and future ages.

The Aqueduct of Alcantara, from its source at Bellas to its termination at Lisbon, is 56,380 feet long. The springs which feed it come from Ribeira de Carenque, Cannessas, and other adjacent places, whence they are conducted, and united to the aqueduct in a small semicircular channel: the water then commences its course at a gentle velocity, augmenting in quantity, by the union of several tributary springs, until it arrives at the valley of Alcantara, where it crosses in a stream of 13 inches wide, by seven inches deep, and thus passes on to Lisbon.

The water-channels are hollowed out of one stone, and cemented at every joint with a composition of finely powdered brick, free-stone, and lime-stone, mixed up with oil and turpentine.

Throughout the whole course of this stupendous work, the utmost skill is visible in preserving the inclination, and in the masonry; but the circuitous windings, subterraneous passages, and numerous arches, offer but indifferent specimens of hydraulic art. Of the former there are 65 angles, and of the latter 127 arches. Light and air are admitted into the vaulting enclosing the channels, by windows and towers placed at certain intervals, which are furnished with close iron gratings, to prevent the admission of noxious ingredients.

The middle arch, (which is 220 feet high and 108 wide) as well as all the other arches, are extremely well executed; and in standing at the western angle, the eye ranges over the piers, without the slightest variations of any of them from the vertical plane. The joints are close, and the horizontal lines well preserved. The voussoirs of the arches appear of equal length, and their extrados are adapted to the courses of 16 inches deep each. Those of the middle arch appear about eight feet in length, and 15 of them constitute the depth of the work; but the four ranks of projecting stones, which probably carried the centreing, hurt the uniformity. The only perceptible sinking occasioned by the earthquake is in the north parapet and in one of the towers. A stream, or rather winter-torrent, runs through the channel under the great arch, and empties itself into the Tagus, about two miles distant. The width of the section at top is 30 feet one inch, and at bottom 25 feet 10 inches.

The steepest or eastern bank is the Lisbon side, and the gently rising or western bank the Bellas side; the spectator will then face the south. A statue of John V. is represented in Roman costume on a pedestal on the eastern end, where the foot path commences, from which to the arch No. 1, is 570 feet seven inches solid wall.

The valley of Alcantara is fertile but not picturesque; Hoffmanzeg discovered several plants peculiar to the tropical regions; and the botanist L'Ecluse spoke enthusiastically of its productions; but with the exception of the orange plantations near the stream, the features are rough and uninteresting. The heat in the valley is too powerful for vegetation, and were it not tempered by the prevailing north winds of the summer season, it would be insupportable.

The water of the aqueduct has a fine clear appearance; but it holds a large portion of carbonate of lime in solution, which gradually deposits in concentric rings in the interior of the pipes, until their area becomes reduced to a small hole of the size of a pin's head. The pipes being of lead are then ripped open and folded back, leaving a nucleus as hard as the original stone. The inspector says each ring denotes one year.

With regard to the reservoir, it is a large square building to which the aqueduct joins, by several semicircular arches of about 60 feet span, and into which the water from the channel was to flow in a cascade, and thus fill it up to 25 feet in depth. But it was afterwards judged to be unsafe, from the internal pressure being likely to force the walls, and do mischief in the city, which, from being completely commanded by the reservoir, might be incalculable.

The internal dimensions of the cistern are 92 feet seven inches, by 79 feet 10 inches, and 25 feet deep. Four stone piers of eight feet square, rise from the bottom of the cistern, to support the brick vaulting above, which is still unfinished. The floor is finely laid, and the sluices well executed. The view from the summit of this building is superb, presenting every feature of a fine landscape.

On the external face of the south side of it, a marble tablet contains the following inscription.—Joannes V. Lusitanorum Rex Magnificus Liberalis Civitate Profitens Excipiendis Aquas Populo Manantibus Hanc Molem Struendam Curavit Orbis Miraculam Tanti Nominis Æternitatis.

Poor M. Goguet, and the good folks in this country who have copied his error into children's geographical books, have greatly mistaken the power of arithmetical numbers, and the physical powers of man also, when they tell us that the canal of Languedoc occupied 100,000 men 30 years in its construction. Now out of this canal there were scooped 2,000,000 cubic fathoms of earth. But one man might dig one cubic fathom in a day; therefore 100,000 men at once at work would have completed the whole canal, digging, pathways, embankments, and locks, in at most one month! — Let us, however, pass from the marvellous of M. Goguet, and the simplicity of his copyists, to structures not less wonderful than the bridge of Alcantara, though we cannot prophecy they will have the same durability.

35. *Wire-Bridge, near Philadelphia.*

This Bridge is supported by six wires, each 3-8ths of an inch in diameter—three on each side of the bridge.—These wires extend, forming a curve, from the garret windows of the wire factory to a tree on the opposite shore, which is braced by wires in three directions.

The floor timbers are two feet long, one inch by three, suspended in a horizontal line by stirrups, of No. 6, wire, at the ends of the bridge, and No. 9, in the centre, from the curved wires. The floor is eighteen inches wide, of inch board, secured to the floor timbers by nails, except where the ends of two boards meet; here, in addition to the nails, the boards are kept from separating by wire ties. There is a board, six inches wide, on its edge, on each side of the bridge, to which the floor timbers are likewise secured by wires. Three wires stretched on each side of the bridge, along the stirrups, form a barrier to prevent persons from falling off. The floor is 16 feet from the water, and 400 feet in length.—The distance between the two points of suspension of the bridge is 408 feet.

The whole weight of the wire is - - - - -	1314lbs.
——————————— wood work - - -	3380
——————————— wrought nails - -	8
Total weight of the bridge	4702lbs.

Four men, it is said, would do the work of a similar bridge in two weeks of good weather, and the whole expence would be about three hundred dollars.

36. *Iron hanging-bridge over the Menai Strait.*

It has long been a great desideratum to facilitate the communication between Great Britain and Ireland; so that letters, &c. might not be retarded by the uncertainty of the winds as they are now, and have hitherto been. Accordingly after a number of plans for the erection of a bridge over the Menai Strait, between Canarvonshire and the Isle of Anglesea; that of constructing an *Iron-hanging bridge*, has been adopted by the advice, and under the direction of Mr. Telford.

Mr. Telford has, for many years past, bestowed great pains and considerable expense in making a vast number of experiments upon rods of malleable iron, viz. from thirty to nine hundred feet in length, and from one-twentieth of an inch to two inches in diameter, and these both in regard to elementary parts, and also when combined, partly by welding and partly by jointing in a model. Bars of iron were fixed at certain distances, with certain degrees of curvature, and weights hung upon them in the middle, and in different parts, till they broke. To separate a square bar of an inch and five sixteenths required the weight of forty-eight tons, and it required forty-three tons and a half to break a bar of an inch and three-eighths in diameter. Some bars of an inch in diameter, of a foot long, stretched nearly three inches before they broke; and bars of three feet long, and one inch square, sometimes lengthened as much as eight inches before they gave way.

Iron has this peculiar property, that a certain weight extends the length of the bar. After standing some time, the bar remains of that length, and it requires an additional weight to give it an additional strength; so that, although the actual dimensions of the sectional area of the bar become less yet it bears a greater weight. Hence, should any one of the bars in this hanging-bridge, when first placed there, bear a greater weight than the one next to it, or any other bar, and be exposed to a stretch, it would soon accommodate itself to the length of the whole; and, in that state, be capable of bearing more weight than it did at first. Half-inch bars, of tolerably good iron, will bear from six tons to six and a half; but they will elongate at not much more than half that stress. It is a curious fact, that frequently, at the moment of rupture, the bar acquires such a degree of heat in the fractured part, as scarcely to allow a person to hold it grasped in his hand without a painful sensation of burning.

Mr. Telford has also combined iron into the shape in which he has proposed to make the cables for the Menai Bridge, and tried experiments upon it in a model of fifty feet in length. The greater part of these experiments he performed, not by the intervention of a machine, but by absolute weight,—tearing the iron to pieces in that manner.

The iron hanging-bridge to be constructed over the Menai Strait, is to consist of one opening of 560 feet between the points of suspension, and 100 feet in height between the high-water line and the lower side of the road-way; and the road way being horizontal, this height is uninterrupted for the whole 560 feet, except where the natural rock, which forms the western abutment, now interposes. But in addition to these 560 feet, there are to be four arches on the western, and three on the eastern, side of the main opening, each fifty feet span, that is, making in all, 850 feet.

In regard to the navigation, it is far preferable to any bridge of an arched form, because the latter affords the full height of 100 feet only in the middle; whereas the former, as has just been observed, affords the same full height for the whole of the 500 feet, which will be a considerable advantage to vessels passing the Menai Strait, as it will allow them to stand closer to either shore while passing under the bridge. In regard to economy, this bridge, on the principle of suspension, has equally the advantage, the estimated expense not being more than 70,000*l.*: whereas the cheapest of the arched form, made of cast iron, would have cost nearly double that sum.

The road-way will consist of two carriage-ways, each twelve feet in breadth, with a foot-path of four feet between them so that the platform will be about thirty feet in breadth. The whole is to be suspended from four lines of strong iron cables by perpendicular iron rods, placed five feet apart, and these rods will support the road-way framing. The suspending power is calculated at 2016 tons, and the weight to be suspended, exclusive of the cables, is 342 tons, leaving a disposable power of 1674 tons. The four sides of the road-ways will be made of framed iron-work, firmly bound together for seven feet in height, and there will be similar work, for five feet in depth below the cables. The weight of the whole bridge between the points of suspension will be 489 tons.

It is calculated that the contraction and expansion of the iron cables may occasion a rise or fall to the extent of four or five inches; but the variations of the temperature of the atmosphere will not derange the bridge.

The two piers will be sixty feet by forty-two and a half wide at high-water mark, having a foundation of rock. These piers, when connected with the whole of the remainder of the masonry, will form a mass constructed with blocks of hard lime-stone, of much greater weight than is necessary for supporting a bridge of this kind. Upon the summit of the two main piers will be erected a frame of cast iron, of a pyramidal form, for the purpose of raising the cables from which the bridge is to be suspended. As the cables will be carried from the top of the pyramids so as to form nearly similar angles on each side, the pressure will be almost perpendicular.

Along each line there will be four cables, making in the whole sixteen; these cables will pass over rollers fixed on the summits of the pyramids, and be fastened at their extremities to an iron frame, lying horizontally over the top of the small arches, and under a mass of masonry.

From these cables the road-way will be suspended by vertical iron rods, connected at their lower extremities with wrought iron bars, both transversely and longitudinally, thus forming a frame on which timber will be laid for the road-way. The distance of five feet is kept between the rods, in order that the suspending power may be equally distributed throughout the whole length of the bridge. The suspending rods will pass between the cables, and depend upon each two of them, so that the general strength of the bridge could not materially be affected by taking one away. The cables and the flooring, as well as the suspending rods, will be constructed and united in such a manner, that each of the parts may be taken out and replaced separately; so that there can be no difficulty in repairing any part of the bridge, whenever required. A temporary wire-bridge will be made from one abutment to the other, in order to carry over the cables, and arrange the several parts of the bridge, while building.

The weight of each separate cable between the points of suspension is estimated at nine tons and three quarters, or 117 pounds per yard. The weight of a drove of oxen is calculated at about 300 tons, supposing them to amount to 200 head, all closely huddled together; and the estimated weight necessary to tear the cables asunder is upwards of 2000 tons, which is about four times the weight of the entire bridge. The passing of a mail-coach over the bridge is not expected to produce any undulation, or sensible perpendicular vibration; nor is any lateral vibration apprehended from the most violent gale of wind, by reason of the proportion that the breadth of the bridge bears as a frame to its extreme length. The bars, as well as the segments, are each to be joined longitudinally to the whole of the required length, and secured by bucklings every five feet, and then enveloped in flannel, well saturated with a composition of rosin and bees-wax, to preserve them from the weather, and the whole are to be encircled with iron wire.

If the first of the two next articles perpetuates the name of a man inferior to few that antiquity boasts of, the science has a surprising degree of singularity to recommend it to the reader's attention; for in the various methods we may have to contemplate the abridgment of human labour, there is scarcely any in which it appears so rudely sketched as in the Slide of Alpnach.

37. *Statue of Peter the Great, at Petersburg.*

In the year 1782, Catherine, Empress of Russia, erected an equestrian statue of Peter the Great, at St. Petersburg, on an enormous pedestal of granite. It was executed by Monsieur Falconet. When Falconet had conceived the design of his statue, the base of which was to be formed by an huge rock, he carefully examined the environs of Petersburg; after a considerable research, he discovered a stupendous mass of granite, half buried in the midst of a morass.

The expence and difficulty of transporting it were no obstacles to Catherine II. By her order, the morass was immediately drained, a road was cut through a forest and carried over the marshy ground, and the stone, which after it had been somewhat reduced, weighed 1500 tons, was removed to Petersburg. This more than Roman work was, in less than six months from the time of its discovery, accomplished by a windlass and by means of large friction balls, alternately placed and removed in grooves fixed on each side of the road. In this manner it was drawn, with forty men seated upon its top, about four miles, to the banks of the Neva; there it was embarked in a vessel constructed on purpose to receive it; and thus conveyed about the same distance by water to Petersburg.

When landed at Petersburg, it was forty-two feet long at the base, thirty-six at the top, twenty-one thick, and seventeen high; a bulk greatly surpassing in weight the most boasted monuments of Egyptian or Roman grandeur. The statue is of bronze, of a colossal size. It represents Peter the Great in the attitude of mounting a precipice, the summit of which he has nearly attained. He appears crowned with laurel, in a loose Asiatic vest, and sitting on a housing of bears' skin; his right hand is stretched out, as in the act of giving benediction to his people, and his left holds the reins. The design is masterly, and the attitude is bold and spirited.

38. *The Slide of Alpnach.*

This singular structure was erected by Mr. Rupp, in 1812, for the purpose of bringing down to the lake of Lucerne the fine pine trees which grow upon Mount Pilatus. The wood was purchased by a company for 3000*l.* and 9000*l.* were expended in forming the slide. The length of the slide is about 44,000 English feet, or about eight miles and two furlongs; and the difference of level of its two extremities is about 2600 feet. It is a wooden trough, about five feet broad and four deep, the bottom of which consists of three trees, the middle one being a little hollowed; and small rills of water are conducted into it, for the purpose of diminishing the friction. The declivity, at its commencemect, is about $22\frac{1}{2}°$.

The large pines, with their branches and boughs cut off, are placed in the slide, and descending by their own gravity, they acquire such an impetus by their descent through the first part of the slide, that they perform their journey of eight miles and a quarter in the short space of six minutes; and, under favourable circumstances, that is, in wet weather, in three minutes. Only one tree descends at a time, but, by means of signals placed along the slide, another tree is launched as soon as its predecessor has plunged into the lake. Sometimes the moving trees spring or bolt out of the trough, and when this happens, they have been known to cut through trees in the neighbourhood as if it had been done by an axe.

When the trees reach the lake, they are formed into rafts, and floated down the Reuss into the Rhine.

Obs. If the Chronicle Hills, the catacombs, tumuli of Egypt, and curiosities of other places, have excited our wonderment and instructed our judgment; the contemplation of relicts from among a people that are of yesterday in comparison of the Asiatics, cannot fail to gratify those who have been amused with the preceding articles of this book; and with these we will conclude our selections of Architectural monuments.

39. *Remarkable Mummy found in the large Nitre Cave in Kentucky.*

There is now in the City of New York a remarkable human mummy, or exsiccation, found lately in Kentucky. It is thus described in a letter from Dr. Mitchell to S. M. Burnside, Esq. secretary of the American Antiquary Society.

I offer you some observations on a curious piece of American antiquity now in New-York. It is a human body, found in one of the lime-stone caverns of Kentucky. It is a perfect exsiccation; all the fluids are dried up. The skin, bones, and other firm parts are in a state of entire preservation.

In exploring the calcareous chamber in the neighbourhood of Glasgow, for salt-petre, several human bodies were found enwrapped carefully in skins and cloths. They were inhumed below the floor of the cave; and not lodged in catacombs.

These recesses, though under ground, are yet dry enough to attract and retain the nitric acid. It combines with lime and potash; and probably the earthy matter of these excavations contains a good proportion of calcareous carbonate. Amidst these drying and antiseptic ingredients, it may be conceived that putrefaction would be stayed, and the solids preserved from decay.

The outer envelope of the body is a deer skin, probably dried in the usual way, and perhaps softened before its application, by rubbing. The next covering is a deer skin, whose hair had been cut away by a sharp instrument, resembling a hatter's knife. The remnant of the hair, and the gashes in the skin, nearly resemble a sheared pelt of beaver. The next wrapper is of cloth, made of twine doubled and twisted; but the thread does not appear to have been formed by the wheel, nor the web by the loom. The warp and filling seem to have been crossed and knotted by an operation like that of the fabrics of the north-west coast, and of the Sandwich islands.

The innermost tegument is a mantle of cloth like the preceding; but furnished with large brown feathers, arranged and fastened with great art, so as to be capable of guarding the living wearer from wet and cold. The plumage is distinct and entire, and the whole bears a near similitude to the feathery cloaks now worn by the nations of the north-western coast of America.

The body is in a squatting posture, with the right arm reclining forward, and its hand encircling the right leg. The left arm hangs down, with its hand inclined partly under the seat. The individual, who was a male, did not, probably, exceed the age of fourteen, at his death. There is a deep and extensive fracture of the skull, near the occiput, which probably killed him. The skin has sustained little injury; it is of a dusky colour, but the natural hue cannot be decided with exactness, from its present appearance. The scalp, with small exceptions, is covered with sorrel or foxy hair. The teeth are white and sound. The hands and feet in their shrivelled state are slender and delicate.

There is nothing bituminous or aromatic in or about the body, like the Egyptian mummies, nor are there bandages around any part. Except the several wrappers, the body is totally naked. There is no sign of a suture or incision about the belly; whence it seems that the viscera were not removed. It may now be expected that I should offer some opinion as to the antiquity and race of this singular exsiccation.

First, then, I am satisfied that it does not belong to that class of white men of which we are members.

2dly. Nor do I believe that it ought to be referred to the bands of Spanish adventurers who, between the years 1500 and 1600 rambled up the Mississippi, and along its tributary streams.

3dly. I am equally obliged to reject the opinion that it belonged to any of the tribes of aborigines, now or lately inhabiting Kentucky.

4thly. The mantle of feathered work, and the mantle of twisted threads, so nearly resemble the fabrics of the indigenes of Wakash and the Pacific islands, that I refer this individual to that æra of time, and that generation of men, which preceded the Indians of the Green-River, and of the place where these relics were found. This conclusion is strengthened by the consideration that such manufactures are not prepared by the actual and resident red men of the present day.

CHAPTER II.

THE FINE ARTS.

40. A GENERAL knowledge of these is not only considered a necessary accomplishment, but is found to be highly useful in the study of universal science. To a manufacturing and commercial people the cultivation of the fine arts is important in a political point of view. They bestow a greater value on their own productions, by the taste displayed in their knowledge, and by greatly facilitating various processes and operations in the arts of life; on these accounts a brief description of some of the most useful branches of the fine arts belongs to a treatise of philosophical science.

DRAWING.

INTRODUCTION.

41. Drawing is the accurate representation of the colours or outlines of objects. This art forms the basis on which other acquirements must be built.

Obs. To treat fully of this branch of knowledge would exceed the limits of these volumes, but for the benefit of those who have no opportunity of receiving regular instrctions, we shall comprize into as small a compass as possible, such directions and rules as may be easiest understood and most readily applied to practice.

Various opinions have been given as to the best modes of beginning to learn drawing; and it is no easy matter to decide upon a point where much must always depend upon the genius, the turn of mind, and the opportunities of the student, for general purposes, and, where circumstances admit, the study of geometry and perspective should precede all attempts to draw figures and landscape.

Geometry is the best introduction to a knowledge of *form*, as it gives accurate ideas respecting simple bodies, of which others may be considered compounds: and perspective seems necessary not only to enable us to draw the representations of regular objects, but to see them correctly; none unacquainted with its rules can ever draw without committing the grossest mistakes.

SECTION I.

IMPLEMENTS FOR DRAWING.

42. These are drawing-boards, rulers, squares, compasses, pencils, chalks, paper, &c.

Upon drawing-boards we fix and stain the paper, so that it may not shift, and that the colours when laid may not cause it to swell up, and become uneven.

The simplest sort is of a deal board framed square, with a strong piece across each end, to prevent warping. Upon this board the paper may be fixed down with pins, wafers, or sealing-wax; or it may be stained with paste or glue, in the following manner. Wet the paper with a sponge, lay it upon the board, turn up the edges about half an inch, run a little good paste or glue round on the under side, and press the paper down on the board with a cloth; then set it by to dry, and the paper, which had expanded much when wet, will contract in drying and stain flat and tight.

But the best drawing-boards are made with a frame and a moveable pannel, upon which the paper is put wet, and the whole forced into a frame, where it is continued by wedges at the back. This method stains equally well, without pasting, and it also looks much neater. These drawing-boards are sold at colour-shops.

Parellel rulers, for drawing parellel lines, are made of two pieces of wood fastened together by brass bars, so as always to move parallel to each other. They are sold at different prices by mathematical instrument makers.

The-squares are rulers made in the form of the letter T, and used with drawing-boards. The short end, called the stock, is applied to the edge of the board, so as to slide forwards and backwards. The long part, called the blade, is that by which we draw lines. When a drawing-board is used, these are more convenient than parallel rulers, as you draw lines at right angles to each other, without the use of compasses.

Dividing Compasses are made of brass and steel, for dividing lines, and laying down measures from scales, &c.: they are generally sold in cases, containing also a steel drawing pen and points, with a black-lead pencil, for putting into the compasses when circles are to be described. These cases also contain scales of equal parts, and protractors for laying down angles.

Black-lead Pencils are made of a mineral substance called plumbage, or black-lead, a carburet of iron, sawed into slips, and fitted into sticks of cedar.

Black-lead pencils are of various qualities. The best are fine, without any grit, and cut easily without breaking. An inferior kind, made by mixing up the dust of black-lead with gum or glue, are always gritty, and do not answer well for drawings, yet, being cheaper, may be used upon many occasions. Before buying any quantity of pencils, they should be examined by cutting one of them, because the composition-pencils, having the same outward appearance, are often sold as high as the best.

Indian-rubber, or elastic gum, a substance very much like leather, has the curious and useful property of erasing lines drawn with black-lead, and is therefore much used for this purpose.

It is brought chiefly from South America, in the form of small bottles, originally the juice of a tree that grows abundantly in Surinam; the gum, like milk, is exuded from the tree, and soon becomes solid when exposed to the air. The natives form balls of clay, smear them over with this gum, and when one one coating is almost dry, they apply another, and so on till it is as thick as they desire; they then moisten the clay with water, which does not dissolve the Indian-rubber, and wash it out. We even see the clay on the bits of rubber which we buy in the shops. These bottles are used by the natives for holding water or other liquors. Indian-rubber, as its name imports, is a production common to the East Indies also, whence it is imported in various forms, more convenient for use than the bottles we have mentioned.

Indian-Ink comes from China, where it is used for common writing, which is there performed with a brush instead of a pen. It is a solid substance, of a brownish black colour; the composition is not known.

When ground with water, upon a clean tile or earthenware plate, it may be made either lighter or darker, as required, by adding to it more or less water. The best Indian-ink, stamped with Chinese characters, breaks with a glossy fracture, and feels smooth when rubbed against the teeth. An inferior kind, made in this country, of lamp-black or ivory-black, ground up with gum, may be easily known by its grittiness.

Hair-pencils made of camels' hair put into a goose or swan's quill, may be ascertained good by the following experiment: moisten them a little, and if they come to a point without splitting, they are good; if they do not, they are not fit for drawing with. The Chinese brushes, made of a white hair pushed into reeds, are very excellent for drawing.

The *Charcoal* used for slightly sketching in the outlines of figures, in order to get the proportions, previous to making a drawing in chalk, is that of the willow: it is cut into slips, and the strokes it makes may easily be rubbed out with a feather from a duck's wing.

Black Chalk, a fossil substance, resembling slaty coal, is cut into slips for drawing, and generally used in an instrument called a *port-crayon*, made either of steel or brass.

Black Chalk is much used for drawing figures, and it is the best substance for this purpose, in making drawings from plaister, or after living models. It is more gritty than black-lead, but of a deeper black, without the glossiness of the former. There are two kinds, French and Italian; the former soft, the latter hard. But for mellowing and softening the shadows into each other when black clalk is used, *Stumps* are necessary. These are merely pieces of soft shamois leather, or blue paper, rolled up quite tight, and cut to a point.

White Chalk used for laying on lights, is different from common chalk, being much harder. But should it not be conveniently procured, tobacco-pipe clay will do very well instead of it.

Red Chalk, a fossil substance of a red ochrey colour, is sometimes used for drawing, but the black is preferred.

Drawing-paper. There are various kinds of drawing-paper; but any paper that will do for writing will do for drawing. However, as the wire-marks in common writing paper are injurious to the shadings of drawings, paper made without any wire-marks, called *wove paper*, is generally used for this purpose. This wove paper is of various sizes and thicknesses. But the manufacture, &c. of paper we have elsewhere treated.

SECTION II.

PERSPECTIVE.

43. Perspective teaches us to draw the outlines of objects upon a plane surface, so as to give the same representations to the eye as the objects themselves present in nature.

Obs. We suppose the student is master of geometry, which with perspective should precede all other kinds of drawing, whether that of the figure, landscape, flowers, architecture, machinery, &c. Though the utility of geometry may not appear equally evident in all these, yet there are many cases in each where it is indispensable; and an acquaintance with perspective will save the trouble of wrong thinking, and will enable you to avoid many errors which you would otherwise fall into.

DEFINITIONS.

1. The *perspective plane* is the surface of the picture itself. This plane is supposed to be of glass, as a pane in a window, placed perpendicular between the spectator and the objects to be drawn.

If rays or lights be supposed to come from every part of the objects to the eye, when viewing them through the glass, they would pass through the plane in certain points; and if these points were collected by lines, they would give the perspective representation. On this idea all the rules of perspective are founded: and these rules are but so many methods of finding out the points; but when the light, shadow, and colour are added, the whole constitutes a picture resembling the original.

2. *Visual rays* are rays of light arising from the different parts of an object at our eyes; by means of these rays we see the object, or it is painted on the retina of our eye.

3. The *point of sight* is the spectator's eye, not the *centre of the picture.*

4. An *original line,* is any line in Nature, or in the objects tc be drawn in perspective.

5. An *original plane* is any surface of the objects to be represented.

6. The *vanishing point*. If we suppose a line proceeding from the eye, parallel to any line in the object, we are viewing, and continued till it arrive at the picture of a perspective plane, the point where it would touch the plane is called the *vanishing point* of the line.

All lines parallel to each other in Nature, have the same vanishing points, because the same line which would find the vanishing point of one, will do for them all, and form only one point.

7. A *vanishing line*. Could we suppose a plane to proceed from the eye of the spectator, in a direction parallel to any side of an object which he views through the plane of glass, continued till it arrive at the glass, the line it would form by contact with the glass, is the *vanishing line*; and it is the vanishing line of the side of the object to which the supposed plane was parallel.

8. In every *picture* or *perspective plane*, there is a point, which a line drawn from the eye perpendicular to the picture, would touch; this point is *the centre of the picture*, and is the same which some call the *point of sight*.

From its name, we should expect to find the centre of the picture always in the middle of the representation; yet this is not the case, sometimes it is near one of the sides, as in parallel perspective; though in oblique perspective, it is generally in the middle of the picture; strictly, it should be in the middle of the picture when circumstances of convenience admit it; for that is the point which the spectator looks full against, or which is exactly opposite to the eye when he views a picture; and the best way to see a picture is to look directly against its middle. However, in many kinds of perspective drawing, it is not convenient, on account of room, to have this point in the middle, as may easily be imagined by considering Fig. 1. where G is the centre of the picture, and the vanishing point of all lines that are in Nature perpendicular to the picture.

9. The *horizontal line.* If a plane be supposed to proceed from the eye, as before, parallel to the floor or level ground till it arrives at the picture, the line where it meets it, is called the vanishing line of the horizon, or *horizontal line*; as H G, Fig. 1.

This line is of great importance in perspective. The centre of the picture is always somewhere in this line. Its height is regulated by the height of the eye from the ground; in landscapes, and views of places, it is about one third of the height of the picture from the bottom, when we stand upon high ground, the horizontal line rises in proportion. Supposing the view to be taken on level ground, a man's head would come to this line, whether he be near or far off; for wherever his feet are, his head always comes to the horizontal line, if he be standing upright.

10. *Distance of the picture,* means the supposed distance of the eye from the centre of the perspective plane or picture.

This distance is chosen at pleasure, yet a judicious choice is important, as the variation of this distance renders every perspective representation, either pleasing or distorted. Long distances, if they can be attained, give the best representation, but they are not always convenient.

11. *Parallel perspective* is that in which the picture is so situated, as to be parallel to the side of the principal object in the picture, as a building, for instance. The lines on those sides of the building parallel to each other continue parallel on the picture, and do not vanish into any point; as AB, DC, Fig. 1. the lines at right angles to the former, vanish into the centre of the picture; as BE, CF, both of which vanish in G.

12. *Oblique perspective* is when the plane of the picture stands oblique to the sides of the objects represented. Here the representations of the lines upon those sides will not be parallel among themselves, but will tend towards their vanishing point. This species of perspective is shewn in Fig. 1.

13. A *bird's-eye view,* is a view taken in the air, looking down upon the object. It differs from the

common perspective views, in supposing the horizontal line to be raised much higher.

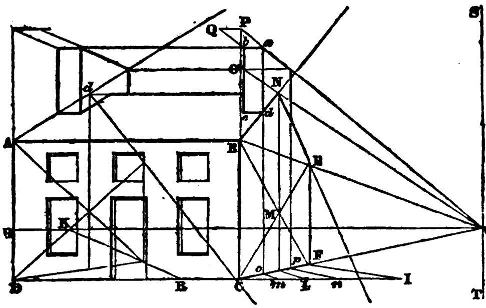
THE PRACTICE OF PERSPECTIVE.

When an object is to be drawn in perspective, all its parts must be measured, that we may lay them down from a scale of equal parts.

Having determined whether it is to be parallel or oblique perspective, the first thing to be learned is the horizontal line, this is put parallel to the bottom of the drawing, and as high above it as the height of an ordinary man's head. Thus HG, in the annexed figure is five feet six inches above the bottom of the house.

Next, determine on the centre of the picture G, which we place so as to leave convenient room for the representation. Fix on C the nearest corner of the object, and draw the perpendicular CB: lay off CD equal to the length of the building, and draw DA and AB. From C, the nearest corner, draw CG to the centre of the picture. CG contains the line which represents the bottom of the end of the house; this however is an indefinite representation, the exact length of which we do not yet know. The method of determining this is as follows: continue the line DC to I, make CI equal to the width of the house. From G, set off GK equal to the distance of the picture, the choosing of which must be regulated by taste. Draw IK, cutting CG in F, then is CF the perspective width of the house, which was equal to CI. To find the middle of the end of the house, divide CI into two equal parts in L, and draw LK, which will cut CF into two equal parts perspectively. Or draw the lines BE and CF to the centre of the picture, and the diagonals EC, BF crossing in M, then raise the perpendicular MN, in the middle of the gable-end.

To find the height of the gable, lay its actual height BO, above BE, upon the corner line CB continued, draw OG, which crossing the perpendicular MN, gives N, the point of the gable. The top of the chimney is drawn in the same manner, by laying its real height, taken from a scale on OP, and drawing PG, lay off L*m* and L*n*, each equal to half the width, and draw from these points to the distance point K; this will cut the bottom of the house CF, in the points *o* and *p*; from which the perpendiculars, give the perspective width of the chimney. To obtain its thickness, we lay off PQ equal to its thickness, and draw QG; then drawing from *a* the line *ab*, the exact width of the chimney is obtained. From *b* draw *bc*, and from *d* draw *dc*.



The other end of the gable may be drawn by two different methods: first, by supposing the front of the house transparent, and drawing the other end as if seen through it, in the same manner as the end we have described by laying its width from D to R, and drawing to the distance-point K. By raising the perpendicular in the middle, you will meet the ridge-line from the other gable in *d*.

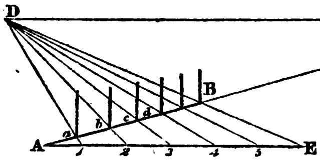
The other method is this: through the centre of the picture G draw a line, perpendicular to the horizontal line HG. Then continue the line of the roof BN till it meets ST in S produced. From A draw AS, which will give the other gable, and S will be the vanishing-point for all lines parallel to B*d* and *ad*; if NE be continued in like manner, it will give T for its vanishing-point.

The doors and windows on the side ABCD, are laid down from a scale, as that side being parallel to the picture, varies not from its geometrical delineation, except shewing the thickness of the *reveals*, or edges of the doors and windows. Had there been any windows in the side BEFC, they would be drawn in perspective by the method used for finding the width of the house and the middle of the end, by laying off the actual dimensions from C upon CI, and drawing from these points to the distance-point K, which would transfer these divisions to the bottom of the house CF, and then perpendiculars might be drawn upwards.

PROBLEM 1. *It is required to divide into any number of equal parts a line in perspective parallel to the horizon, and tending to a vanishing-point. In other words, to divide it in any required proportion.*

Let AB be the line going to its vanishing-point; and let it be required to divide that line into six equal parts. Let CD be the horizontal line, and AE the ground line, parallel to it.

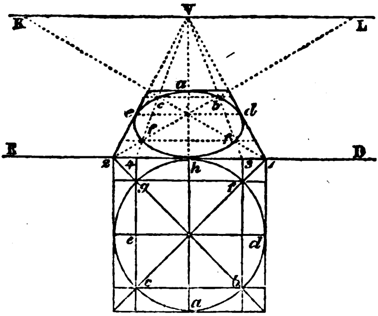
lay off, at pleasure, CD for the picture's distance, if C be its centre.



Draw a line from D, to touch the end B of the line you intend to divide: draw DBE, cutting the ground line in E. Then AE represents the actual dimensions of the line AB seen in perspective. (This principle gives a rule also for finding the real length of any line tending to a vanishing-point). Divide AE into the same number of equal parts into which you proposed to divide the given line AB; as A, 1,—1, 2,—2, 3,—&c. Then from these different divisions draw lines to D, cutting the line AB in *a*, *b*, *c*, *d*, &c., which will represent the required number of equal parts, but diminishing in size as they are farther removed from the eye. Were it wished to divide the line AB into any number of unequal parts, as for doors, windows, &c. the line AE, found as before, is divided into the required proportion, and lines drawn from those to D give the required divisions on AB, from which draw perpendiculars for the doors, windows, &c.

PROBLEM 2. *To draw a circle in perspective.*

The perspective representation of every circle is an ellipsis, when the eye is without the circle. This is obvious, because the rays from the circumference of the circle to the eye form an *oblique cone*. But those who are acquainted with conic sections, know that every section of a cone, whether right or oblique, is a true ellipsis, except when the section is taken subcontrary to its base, a situation which happens so rarely in drawings as to be altogether disregarded, and the section of a cone, or the perspective of a circle, is in all cases considered a perfect ellipsis.



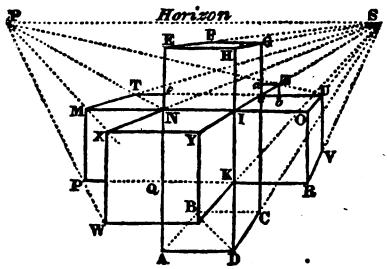
The most correct and easy method of drawing an ellipsis is, to find the transverse and conjugate axes; the curve is then completed by a trammel, or the hand. But as it is difficult to find the transverse and conjugate axes of the ellipsis, which are the perspective, if the circle to be put in perspective be small, describe a square about it. Draw first the diagonals of the square, and then the diameters *h a* and *d e*. cutting one another at right angles; draw the straight lines *f g* and *b c* parallel to the diameter *d e*. Through *b* and *f*, and likewise *c* and *g*, draw straight lines meeting DE, the ground of the picture in the points 3 and 4. To the principal V draw the straight lines 1 V, 3 V, 4 V,—2 V, and to the points of distance L and K, 2 L and 1 K. Lastly, join the points of intersection *a*, *b*, *d*, *f*, *h*, *g*, *e*, *c*, by the arcs *a b*, *e d*, *d*, *f*, and *a b d f h g e c a* will be the circle in perspective. In this process, it is of consequence to know that the curve you trace is a regular ellipsis; for though you cannot easily ascertain the axes *exactly*, yet you may *very nearly;* and the eye soon discovers whether the curve drawn be that of a regular ellipsis.

PROBLEM 3. *To draw any row of arches*

Upon the principle just laid down, the row of arches is drawn. We obtain the width of the arches and piers in the manner shewn in *Fig.* 2, by laying their dimensions upon the ground-line AB, and drawing lines to the distance-point. The curves of the arches are then found, by drawing the lines corresponding to those in half the square, (*Page* 71.) in the manner described above for the circle.

PROB. 4. *To represent a double cross in perspective.*

Let ABCD and EFGH be the two perspective squares, equal and parallel to one another, the uppermost directly above the lowermost, drawn by the rules already laid down, and as far asunder as is equal to the given height of the upright part of the cross; S being the point of sight, and P the point of distance, in the horizon PS taken parallel to AD.



Draw AE, DH, and CG; then AEHD, and DHGC shall be the two visible sides of the upright part of the cross; of which, the length AE is here made equal to three times the breadth EH.

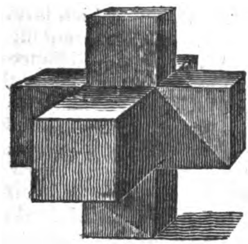
Divide DH into three equal parts, HI, IK, and KD. Through these points of division, at I and K, draw MO and PR parallel to AD: and make the parts MN, IO, PQ, KR, each equal to HI: then draw MP and OR parallel to DH.

From M and O, draw MS and OS to the point of sight S; and from the point of distance P draw PN cutting MS in T; from T draw TU parallel to MO, and meeting OS in U; and you will have the uppermost surface MTUO of one of the cross pieces of the figure. From R, draw RS to the point of sight S; and from U draw UV parallel to OR; and OUVR shall be the perspective square and next the eye of that cross part.

Draw PM, XW (as long as you please); from the point of distance P, through the corner M lay a ruler to N and S, and draw XN from the line PX:—then lay the ruler to I and S, and draw YZS.—Draw XY parallel to MO, and make XW and YB equal and perpendicular to XY: then draw WB parallel to XY, and WXYB shall be the square visible end of the cross part of the figure.

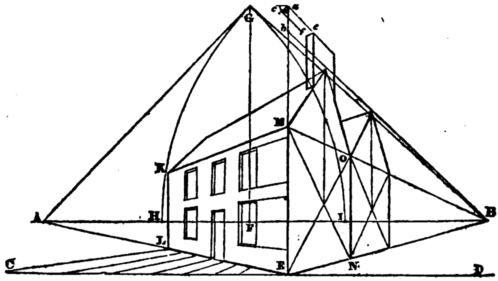
Draw BK towards the point of sight S; and from U draw UP to the point of distance P, intersecting YS in Z: then, from the intersection Z, draw *Za* parallel to MO, and *Zb* parallel to HD, and the whole delineation will be finished.

This done shade the whole, as in the adjacent figure, and you will have a true perspective of a double cross.



PROB. 6.—*To put a building in perspective.*

On the opposite leaf, page 74, you are shewn the method of drawing a building in oblique perspective, AB is the horizontal-line, and CD the ground-line, parallel to it as before. But then neither of the sides of the house is parallel to the picture, as each goes to its respective vanishing-point. Having fixed on the nearest corner E, draw EB at pleasure, for one side, and choose any point F for the centre of the picture; then, to find the other side, lay off FG equal to the distance of the picture, which, as before, depends upon taste only, draw BG, and GA perpendicular to BG, cutting the horizontal line in A, the other vanishing-point: draw now EA for the other side.



To cut off the several widths of the two sides of the house, two distance-points are laid down, viz., one for each vanishing-point. To do this, extend the compass from B to G, and lay the distance taken in it from B to H, which will give H for the distance-point of B, and which is to cut off all the divisions on the side EB. Also extend the compasses from AG, and lay down AI. I is the distance-point of A, and is used for transferring all divisions upon the side EA from the ground-line CE. These points and lines being adjusted, the process is not much different from parallel perspective; only here equal divisions on *each* side of the building, as doors, windows, diminish as they recede in the same way as on the side BEFC of Fig. 1, Page 69.

Lay the *real* length of the side EL, taken from the same scale used for laying down the horizontal-line, and lay it down on the ground-line, from E to C, and to draw CI, cutting off EL, for the *perspective* length of the building.

For the other side of the house, lay its width down in the same manner, from E to D, and draw DH, cutting off EN for the perspective width. Raise the perpendiculars EM, LK, and NO, for the three angles of the house. Lay the height of the building upon the corner that comes to the ground-line, as EM, and draw MK and MO to their several vanishing-points. Also lay all the heights of the doors and windows, and other divisions, upon EM, and draw them to the vanishing-points A and B. To lay down the widths of the doors and windows, put their actual widths upon CE, and draw from them to the distance-point I, which cuts off all divisions upon the side LE, and then raise the perpendiculars.

The gable-end is found exactly in the same manner as was described in Page 69, only taking care to use the proper distance-point H. The manner of finding the width of the chimney is different. Lay off *ba* for the height of the chimney above the top of the gable, and draw *ac* parallel to the horizontal-line; then put *ac* equal to the actual thickness of the chimney, and draw *ad* to the vanishing-point A; draw also *cd* to the distance-point I, cutting off *ad* in *d*: then having drawn *ef* from the nearest corner of the chimney, (which was found as in Fig. 1, Page 69,) draw *df* to the vanishing-point B, cutting off *ef* for the exact perspective width.

Prob. 7. *To find the Perspective of a Circle in oblique perspective.*

Fig. 3, Page 71, KL is the horizontal-line, V the centre of the picture. The process is similar to that just described the several divisions of the reticulated square in Fig. 3, Page 71, being laid upon the ground-line ED, and from these, lines are drawn to the distance-points. The perspective of the square is then drawn with all the lines across it, and the curve traced through the different points.

By drawing these examples frequently over, on a large scale, and reflecting upon them with attention, you will become familiar with their use, and as they include the most frequent cases, you will necessarily find great benefit from their knowledge.

Those who wish to become more acquainted with this science should study some of the treatises written expressly on the subject, on perspective by Dr. Brook Taylor, which is an octavo pamphlet, and must by no means be confounded with the quarto works, entitled, "Brook Taylor's perspective made easy by Kirby," a work of little merit. Those who understand not mathematics, or are unwilling to bestow the necessary trouble of learning perspective, may read an excellent work in folio, by T. Malton; or, if that be too voluminous, a very neat work by Noble; or the small treatises by Fergusson, Priestly, Hayter, and Nicholson.

If the student read with attention, and remember the following recapitulation of some of the principal established rules in perspective, he will find them of assistance in his practice of drawing.

Recapitulation.

1. *Original object* is the object which is to be represented in perspective.

2. *Original planes, or lines,* are the surfaces of the objects to be drawn, or any lines on those surfaces; or it means the surfaces on which these objects stand.

3. *Perspective plane* is the picture itself, which is supposed to be a transparent plane, through which we view the objects that are represented on it.

4. *Visual rays* are the rays of light which proceed from every part of the original objects, through the perspective plane to the spectator's eye, which is fixed.

5. *Point of sight* is the fixed point from which the spectator views the perspective plane.

6. *Vanishing points* are the points which are marked upon the picture, by supposing lines to be drawn from the spectator's eye parallel to any original lines, and produced till they touch the picture.

7. *Vanishing planes* are lines formed on the picture by the intersection of supposed planes proceeding from the eye of the spectator to the picture, parallel to any original lines.

8. *Horizontal line* is the vanishing line of the horizontal plane, and is produced in the same manner as any other vanishing line, namely, by passing a plane through the eye parallel to the horizontal plane.

9. *Centre of the picture* is the point on the perspective plane, where a line drawn from the eye, perpendicular to the picture, would cut it. Consequently it is the nearest point in the picture to the spectator.

10. *Distance of the picture* is the distance from the eye to the centre of the picture.

11. *Distance of the vanishing point* is the distance from the vanishing point on the picture to the eye of the spectator.

12. *Ground plane* is the surface of the earth, or plane of the horizon, on which the picture is supposed to stand.

13. *Ground line* is the line formed by the intersection of the picture with the ground plane.

Theor. 1. The farther any object is from the eye, the smaller is its representation upon the picture, or the smaller is the optic angle under which it is viewed. This is easily demonstrated, and forms the basis of perspective.

Theor. 2. All lines parallel among themselves, but not to the picture, tend to a point in the picture.

Theor. 3. All parallel lines have the same vanishing point.

Theor. 4. The centre of the picture is the vanishing point of all lines perpendicular to the picture.

Theor. 5. The representation of lines, which are parallel to the picture, have no vanishing point.

Theor. 6. The perspective representations of circles are ellipses whenever the eye is without the circle.

Theor. 7. The perspective of circles as well as of other curves, is found by drawing round them reticulated squares, and then having put these into perspective, tracing the curve through the same points in the perspective representation of the reticulation as it passes through in the original.

SECTION III.

DRAWING THE FIGURE.

44. The study of the human figure is considered by artists as the most important because it is the most difficult part of their profession. Its study contributes most to general improvement; but it does not follow that a person who can draw the human figure well, can draw every thing else; there are many artists who can draw the figure very well, who cannot draw landscape nor architecture. To draw a particular subject well, requires particular attention to that class of subjects.

The study of the figure, includes the finest specimens of the art; and when one's eye has been accustomed to copy faithfully all the circumstances which constitute the character and indicate numerous beauties and graceful forms which the human figure presents, he will be better qualified to pursue with advantage other branches of the fine arts.

In learning to draw the human figure, we must begin with each of the parts separately, and after practice in that way, put them together in the complete figure.

The head is the most important part of the human figure, and should first be studied; the student should therefore copy separately, on a large scale the best drawings he can procure of the *eye, mouth, nose,* and *ear;* and of these, a front view, profile or side view, oblique view, &c.

The best material for drawing all parts of the figure, is black-chalk, or black-lead. If the former be used upon white, or middle-tint paper; white chalk may be used for laying on the lights. Black-lead is only used upon white paper. With a piece of soft charcoal slightly sketch in the general form, which must afterwards be corrected with the black-chalk. False black-lead lines may be removed by the Indian-rubber; but be as sparing as possible of this, as it is more improving to endeavour to draw correct and decided at once, than trust to the correction of lines which are wrong.

Shadows are laid on by drawing parallel curve-lines, according to the situation of the part, crossing them occasionally, and softening them in with more delicate lines, where necessary.

All the parts of the human figure are composed of curved surfaces: straight lines therefore cannot be admissible, where every line should have a graceful turn: it is this circumstance that gives those who have studied the figure so much freedom in drawing.

Take care, that no lines cross each other at right angles as such give a disagreeable *net-like* appearance; neither should the crossings be too oblique, else they will become confused: a proper medium is acquired by studying good drawings or prints; in general, crossing should be avoided as much as possible.

The shadows are sometimes rubbed in, or their edges softened with a *stump*, a very expeditious way, that produces a fine effect; but it should be used at discretion, for it is better to execute the shadows by soft lines in a clear and regular manner.

Take care not to make the lines harsh, like those of an engraving; but softer and more mellow. On this account, *drawings* are better to learn from than prints; by copying the latter, you will be apt to acquire a dry and hard manner.

Avoid copying with a pen all the lines used for the shadows in engravings. Some, who have not been accustomed to see good drawings, do this. Productions of this kind executed with immense labour, may be thought very fine by those who have little knowledge of the art, yet good judges always consider them disgusting, and pity the student whose patience and labour have been so misapplied.

In copper-plate engravings, we cannot with effect produce shadows but by lines, this arises from the nature of the process; but in drawing, which is of a very different nature, the same necessity exists not for lines. In general the less labour there appears in any drawing, the better it is; though pains be taken to make drawings or paintings excellent, this labour should be always disguised, and the whole appear as if executed with the greatest ease.

In learning to draw, it is of more importance than is generally supposed, to copy from the finest works only. The most prejudicial quality of a model is mediocrity. The bad strike and disgust; but those that are not good, nor absolutely bad, deceive us by offering a dangerous facility. It is for this reason that engraving contributes to the progress of the arts, when it is employed on subjects that are judiciously chosen; but it is too often prejudicial, by the indifferent works it multiplies without number. But let RAPHAEL be copied by skilful engravers, let a young artist profit by his labours, and works without dignity and expression will soon become intolerable to him; he will perceive to what an elevation the excellence of the art can raise him.

The way to avoid mediocrity, is by the study and imitation of beautiful productions; or, in want of them, of the most finished translations that have been made from them; for so we may call beautiful prints. Let a young draughtsman study the heads of RAPHAEL, and he will not see without disgust the sordid figures of indifferent painters. But if you feed him with insipid substances, he will soon lose the taste necessary to relish great excellencies. In the one case he will advance firmly in his career: in the other he will continually totter, and even not be sensible of his own weakness.

Having copied frequently the parts of a face, you proceed next to the entire head; drawing first a front view, then a profile, then a three-quarter view, and so on; varying it in every possible direction, till you are thoroughly acquainted with the appearance of all the chief lines in every situation. In making these studies, you must be contented at first with drawing *mere outlines*, they are by far the most important, and be it remembered, that to make a *good outline* is always the most desirable attainment.

You should now accompany your lessons by making observations on good *casts* and living models; but more particularly the former; individual nature being seldom fine, there is danger of copying what is bad, and thence acquiring false ideas of beauty.

By these exercises you will acquire some facility in handling your pencil, and be thus prepared for the study of the whole figure. But before you can proceed to this with advantage, study anatomy.

"An artist who is not acquainted with the form and construction of the several bones which support and govern the human frame, and does not know in what manner the muscles moving those bones act, nor of the veins and arteries, further than what appears of them through the integuments with which they are covered, must necessarily entertain limited notions of the human frame; yet the appearance of the whole, is the noblest object of the pencil. It is impossible for an artist to copy faithfully what he sees, unless he thoroughly understands it. Let him employ ever so much time and study in the attempt, it cannot but be attended with many and great mistakes; just as it must happen to a man who undertakes to copy something in a language which he does not understand, or to translate into his own what has been written in another on a subject with which he is not acquainted."

But it is not necessary for you to study anatomy as a surgeon, nor to make yourself acquainted with all the nerves, veins, &c. It is sufficient to study the skeleton, and the muscles which cover it; and, of these make yourself familiar with those muscles which frequently appear and come into action.

For this purpose, procure plaister casts of the anatomy of the human body, and consult treatises written upon the subject; and if you have opportunity, afterwards attend dissections, and lectures on anatomy.

Use every possible opportunity of making observations on the actions of the muscles in nature; as, by being thus thoroughly prepared, you will be enabled to draw the human figure with great advantage, and make more progress than you could have done without these studies.

Symmetry, or *proportion*, is learned by copying antique statues, plaister casts of which may be procured. For, though nature, in the formation of every species, seems to have aimed at the last degree of perfection, it does not appear that she has been equally solicitous in the production of individuals. Hence, though parts of individuals may be as beautiful as possible, we seldom meet with a complete whole.

The Greek statuaries selected from various individuals the most beautiful parts, and by combining them produced figures more beautiful than were ever presented by nature. Let the student, therefore, imbibe a proper relish for beautiful proportions, and be well grounded in their principles before he proceeds to draw from living models.

In drawing from plaister casts, much depends upon selecting a proper view, and placing the model properly with regard to the light; which should fall obliquely from above. If a candle is used, it should be placed sufficiently high to cast the light downwards upon the model, and the light should only come from one part, as cross-lights will distract the shadows, and spoil their effect.

Indefatigable labour and persevering zeal are required to go through all these studies; but when you have acquired a facility of drawing the human figure in every possible situation, and under every variety of form and circumstance, a great deal remains still to be done before you can be considered an artist. You have as yet conquered only the mechanical difficulties: your mind must be cultivated by the study of all the higher and more refined parts of the art. The naturalist and historian draw objects as they find them, with all those imperfections and blemishes to which, as individuals, they are subject; but a painter resembles the poet, whose creative fancy soars above nature, and represents objects endued with all that perfection which belongs to the species, but which is rarely found in the individual.

Imagination and conception are his chief guides, and for a good choice of subjects for the exercise of his pencil, he should enrich his mind with a great variety of knowledge,

historical and poetical, and the customs and manners of ancient as well as modern nations.

The faculty of *invention* should now be continually exercised, and free scope should be given to the sallies of imagination, which, however, should never exceed the bounds of probability.

It is indisputably evident that a great part of every man's life must be employed in collecting materials for the exercise of genius. Invention, strictly speaking, is little more than a new combination of those images which have been previously gathered and deposited in the memory. Nothing can come of nothing; he who has laid up no materials, can produce no combination.

He should study the works of former artists, learn what subjects they have painted, and how they have treated them. A student unacquainted with the attempts of former adventurers, is always apt to overrate his own abilities, to mistake the most trifling excursions for discoveries of moment, and every coast new to him, for a newly discovered country.

On whom, however, can he rely, or who shall shew him the path that leads to excellence? The answer is obvious: those great masters who have travelled the same road with success, are the most likely to conduct others. The works of those who have stood the test of ages, have a claim to that respect and veneration to which no modern can pretend. The duration and stability of their fame is sufficient to evince that it has not been suspended upon the slender thread of fashion and caprice, but bound to the human heart by every tie of sympathetic approbation.

But though these masters should be studied, they should not be servilely followed. The student, instead of treading in their footsteps, should only keep the same road. He should endeavour to invent on their principles and way of thinking; he should possess himself with their spirit; he should consider how they would treat his subject, and should work himself into a belief that they are to see and criticise his picture when completed. Every attempt of this kind will rouse his powers.

Whenever a story is circulated, we form a picture in our mind of the action and expression of the persons employed. The power of representing this mental picture on canvas is called *invention* in a painter.

In the conception of this ideal picture, all the little circumstances are contrived so that they strike the spectator no more than they did the artist in his conception of the story. Thus there must be a principal object, receiving the principal mass of light or shadow; and though a second and third group may be added, with a second and third mass of light, they are all kept subordinate, not to come in competition with the principal.

Simplicity is of the first importance in the *design* or *composition* of a picture. The story should be *distinctly* told, and nothing introduced but what is necessary.

Expression of the passions is among the most difficult and important of the higher branches of the art.

It is not enough to delineate exquisite forms, to give them graceful attitudes, and compose them well together; their actions must be expressed, their countenances must indicate the state of their minds; they must appear to feel, to think, and to be stepping out of the canvas.

In fits of anger, the face reddens, the muscles of the lips puff out, the eyes sparkle; on the contrary, in melancholy, the eyes grow motionless and dead, the face pale, and the lips sink in. This leads us to speak of the *colouring*, which must be regulated by the same general principles as the composition. Avoid gaudiness and glare; let quietness and simplicity reign through the whole work. In landscapes, distinct and unbroken colours, such as green or red, are seldom admissible; the tints must be varied and broken. In historical subjects, distinct colours are employed, but so placed with respect to each other, that the effect of the whole is perfectly harmonious in a good painting.

To dispose the *drapery* forms a considerable part of the painter's study. To make it natural is a mere mechanical operation, requiring neither genius nor taste; where to dispose it so that the folds shall have an easy communication, and gracefully follow each other so as to look like the effect of chance, and yet to shew the figure to the utmost advantage requires the nicest judgment.

In the higher style of painting, the difference in the materials of which the drapery is composed is never remarked; it is simple drapery and nothing more.

When a boy, possessed of good talents, has a strong passion for the arts, nothing will restrain him, and there can be little fear of his doing well, if suffered to follow the bent of his inclination; without this, nothing should induce him to engage in a profession so arduous, and which requires such unwearied application. By the rules of perspective he may learn to draw correct outlines of buildings, and regular objects; but to form fine pictures, which shall affect the mind, is an art that requires *genius*, *taste*, *soul*, and *mind*.

"There is one precept," observes Sir JOSHUA REYNOLDS, "in which I shall be opposed only by the vain, the ignorant, and the idle. I am not afraid that I shall repeat it too often. You must have no dependence on your own genius. If you have great talents, industry will improve them: if you have moderate abilities, industry will supply their deficiency. Nothing is denied to well-directed labour; nothing is to be obtained without it. Not to enter into metaphysical discussions on the nature or essence of genius, I will venture to assert, that assiduity unabated by difficulties, and a disposition eagerly directed to the object of its pursuit, will produce effects similar to those which some call the result of *natural powers*. Though a man cannot at all times, and in all places, paint or draw, yet the mind can prepare itself by laying in proper materials, at all times and in all places.

"I cannot help imagining that I see a promising young painter, equally vigilant, whether at home or abroad, in the streets or in the fields. Every object that presents itself is to him a lesson. He regards all Nature with a view to his profession, and combines her beauties, or corrects her defects. He examines the countenances of men under the influence of passion, and often catches the most pleasing hints from subjects of turbulence or deformity. Even bad pictures themselves supply him with useful documents; and, as LEONARDO DA VINCI has observed, he improves upon the fanciful images that are sometimes seen in the fire, or are accidentally sketched upon a discoloured wall.

"The artist who has his mind thus filled with ideas, and his hand made expert by practice, works with ease and readiness; whilst he who would have you believe that he is waiting for the inspiration of genius, is in reality at a loss how to begin, and is at last delivered of his monsters with difficulty and pain."

"What then," exclaims the inimitable GESSNER, "must be the fate of those who do not join an inflexible labour to an habitual meditation? Let the artist who despises or neglects these important means, make no pretension to the recompense due to active and sensible minds. There is no reputation for him, to whom a taste for his art does not become his ruling passion; to whom the hours he employs in its cultivation, are not the most delicious of his life; to whom the study of it does not constitute his real existence and his primary happiness; to whom the society of artists is not, of all others, the most pleasing; to him whose watchings, or dreams in the night, are not occupied with the ideas of his art; who in the morning does not fly with fresh transport to his painting-room. But, of all others, unhappy is he who descends to flatter the corrupt taste of the age in which he lives; who delights himself with applauded trifles; who does not labour for true glory, and the admiration of posterity. Never will he be admired by it; his name will never be repeated: his works will never fire the imagination nor touch the hearts of those fortunate mortals who cherish the arts, who honour their favourites, and search after their works."

SECTION IV.

LANDSCAPE DRAWING.

45. This delightful branch of the fine arts has become now very fashionable; a circumstance which perhaps may be chiefly owing to the ease with which proficiency in it may be obtained, compared with the application necessary in the study of the figure. But the latter always stand pre-eminent, as the passions, and their effects upon mankind, form the noblest subjects for the pencil. However, the representation of beautiful natural scenes, or of the

elements in commotion, have a powerful influence over the mind, to tranquillize its ideas, or excite terror and astonishment.

The difficulties in this art are not to be undervalued; since a high degree of excellence requires a familiar acquaintance with nature, gained by assiduity in copying all her details faithfully, but with the spirit and imagination of the poet.

Landscapes may be considered as faithful delineations or portraits of places, which are called *Topographical* landscape; or as productions of fancy, in which the artist has selected, like Milton in his Garden of Eden, the beauties of various parts, and combined them into a perfect whole.

In drawing topographical representations, the strictest attention is paid to truth in those objects which form the subject of the picture. In mountainous countries the artist must be a geologist, and among buildings, an architect and antiquarian. His business is with facts! and copying nature, his taste, as an artist, should confine him to the point of view most proper to give an impressive and characteristic representation of his object; to select, among the many parts, such as form real character; and to reject as ineffective, all those circumstances which only crowd and confuse, without tending to the general effect. To give, therefore, a faithful, judicious, and striking view of a place is no mean task, and requires a knowledge of the highest principles of art.

After a sketch has been made from nature, the artist must compose it into a picture; or invent a sky, foreground, and figures, to combine with the principal object, and complete its character as a whole. Some artists have the foreground taken from the spot where the sketch is made, and put into the picture without alteration; but the foreground frequently forms no part of the character of the scene, and is often such as to render it unfit for picturesque composition.

Attention must be paid to the nature of the place, it is not correct to depart so far from truth as to introduce tall trees in a foreground to a place entirely barren; nor lakes and streams in places deprived of moisture. Such licences are improper when the character of a country is given.

Nor ought the artist to hesitate, if it should happen that the nature of the ground is unfit for the composition of his picture, and if he finds that by moving a few paces the foreground would be improved. Should he meet with ground still farther off that answers his purpose better, he should not, by a too scrupulous attention to locality, lose an opportunity of enriching his picture. The resemblance or likeness of the place is not at all injured, but improved by this practice: in moving about, our foreground varies every minute; we can have, therefore, only a general recollection of it. In a word, the foreground in our mental picture is composed of the parts of several.

The *poetical* artist, who, by selecting and combining, forms scenes perhaps superior to what are generally met with in nature, enjoys the full scope of his genius, yet he must not exceed the bounds of probability. He will most generally please if he introduce some circumstances that give a strong degree of truth and nature to his compositions.

In this high walk of the art, few rules can be laid down. Every artist has his own ideas of perfection in the grand style of landscape; few have attempted, still fewer have succeeded; and it is difficult to point out productions as models. The works of POUSSIN, CARACCHI, TITIAN, and other masters of the Italian schools, furnish many useful hints; but in studying them the student must not become an imitator and mannerist; losing sight of nature, the contemplation of which alone will stamp his compositions with originality.

In learning to draw landscapes, some masters recommend the copying good drawings before recourse be had to nature; as general notions of the art must be acquired, and a certain facility in execution, and the use of material before nature be attempted. But it is of importance here that what he copies *first*, should be *excellent*; it is absurd to imagine that indifferent drawings will have any other effect than to give a bad taste.

In choosing drawings to copy for beginners, select those in which the outlines or forms of the objects are distinctly and correctly drawn, not those in which a *good effect* only has been aimed at. The first thing to be studied, is to express with the black-lead pencil decidedly and truly, the forms of objects; till this is attained, no attempt should be made at finishing.

Black-lead is the most useful material for drawing the outlines of landscapes. They should be executed with this alone, and not gone over afterwards with a pen, which gives an appearance of harshness.

Indian ink should be used for the shadows till the student has very considerably advanced, nor till then should colours be used. Beginners always desirous of producing pictures and making coloured drawings; must first learn to draw forms correctly; next, the mode of shadowing objects truly; then the general light and shadow of a drawing, and with this good composition. This is best learned by using black-lead, black-chalk, white-chalk, Indian-ink, separately or combined, according to taste; but never colours, till considerable progress has been made in the art.

Colours should be used with caution and judgment, as nothing is so disgusting as to see drawings where the reds, greens, and blues, are laid on without regard to harmony. Those who execute these vile daubings, say that nothing can be greener than grass, nor bluer than the sky; but Nature employs a multitude of little shadows, and a variety of different tints intermixed with her colours, so that the harshness of the original colour is corrected, and the effect of the whole very far from a raw and distinct design laid on paper.

Though we should have recourse to Nature in preference to any master, for the study of colouring, it requires judgment to know what part of Nature is to be studied, and what is to be avoided; for in Nature herself, there are parts which to copy would do more harm than good. In colouring, the student must examine, with attention, the appearance of old walls, broken by time and stained by the weather, old thatch, old tiles, rotted wood; and objects covered with moss, stains and tints of various kinds; here all that is most perfect and harmonious in colouring is to be copied, with every possible care, new buildings, new railing, and objects of an uniform colour, are to be avoided as bad. All the great masters, who have excelled in this part of the art, have adopted this practice. In short, after learning the first principles of drawing, he cannot too soon have recourse to Nature, from whom he will obtain the materials of excellence, in a greater degree than from the first masters. As the study of these will abridge, it should go hand in hand with that of Nature. The fewer colours used in drawing, the better; since harmony is thereby most easily preserved: and by the mixture of a few, every possible tint in nature may be given to her copy.

The primitive colours consist only of three, red, blue, and yellow; so that all the variety of tints in Nature, is formed by the mixture of these in various proportions. And had we pigments of these colours perfectly pure, we should have no occasion for more; but this is not the case, and therefore we have recourse to materials of other broken tints. The colours most useful in drawing landscapes in water-colours, are *lake, indigo, Prussian-blue, gamboge, light red, yellow-ochre, burnt terra Sienna, burnt umber,* and *Cologne earth.*

The water-colours are those mixed with gum, and made up into cakes, to be used by rubbing upon a tile, as Indian-ink is used.

In *picturesque* subjects, as cottages and rustic scenery, *straight* lines must be avoided, and every thing *regular* and *formal.* In general, all that is old and broken, as affording more variety, is preferable to what is new. Old thatch, old tiles, old plaister, old fencing, are *picturesque,* and fit for the pencil; the same species of objects, when new and entire, are stiff and formal. An old house, broken down and ruinous, bulging out in some parts, and the whole stained and tinted with chaste and harmonious colours by the hand of time, is preferable, for a picture, to any new building.

An old worn-out cart-horse is a fitter animal to draw from, and a finer subject for the pencil, than a sleek poney; and an ass, with a rough coat, is more picturesque, than the same animal well brushed and clean. In short, every thing smooth, clean, and new, is not *picturesque,* those objects only are fit studies for a painter which have suffered from accident and time.

In subjects that are magnificent, as newly erected buildings, cities, streets, &c. straight lines are often necessary and proper, these objects being rather of the *sublime* than the *picturesque* kind; and straight lines, with a degree of regularity, are compatible with the sublime.

SECTION V.

MECHANICAL DRAWING, &c.

46. Mechanical drawing is the application of geometrical rules to the various branches of this fine art. In receiving instructions for the study of mechanical drawing, the student must pay attention to every particular branch of his art, to which he wishes to apply himself.

Should circumstances lead him to study architecture, machinery, or the delineation of regular objects, he must then begin by learning geometry and perspective, sciences which afford him the only means of drawing with accuracy. He must next learn to draw plans, elevations, sections of buildings, and all the architectural mouldings and ornament which embellish these buildings. An acquaintance with architectural mouldings is necessary, even if he wish only to draw machinery, or mechanical apparatus; for mouldings borrowed from architecture are used in all kinds of furniture, machines, and every species of apparatus. The student, who is not well acquainted with the forms of these little ornaments and parts, will continually be puzzled in drawing them.

Drawing by geometrical rules, being nothing more than *mechanical drawing*, genius or taste has nothing to do with its various processes. It is an art wholly mechanical, which, like writing, may be acquired by persons of very moderate talents. But this branch of drawing is a useful rather than an ornamental art. It should therefore be learned by all persons, since it answers the same purpose as writing, but much more perfectly wherever it is applicable.

This is particularly striking in drawings of apparatus, and machinery. All written descriptions of those objects are imperfect; whereas a drawing conveys, at a single glance, more information than can be given by words. In short, this branch of the art should always form a part of common school-education, in the same manner as writing, and those who are concerned in the management of our seminaries, and neglect to instruct all their pupils, without exception, in the practice of mechanical drawing do not perform their duty to society.

The rules of geometry and perspective teach us not only to draw correctly the outlines of regular objects, but even the forms and intensity of the various parts of the shadows of such objects may be found by certain invariable rules, founded upon the principles of the incidence and reflection of the rays of light. According to these rules should all geometrical drawings be shadowed.

The writings of my worthy friend Mr. Peter Nicholson are the only works which have merited the public sanction on the subject of mechanical drawing.

THE MECHANICAL MEANS OF COPYING DRAWINGS.

47. There are various methods by which those ignorant of drawing, may copy very accurately the outlines of pictures, these methods are often useful even to those who can draw, and to engravers, when expedition or accuracy is required; but none of them should be used by young people learning to draw.

48. *To draw by the Camera Obscura.*

The Camera Obscura is an optical machine, which, used in a darkened chamber, so that the light coming only through a double convex lens, represents the opposite objects inverted upon any white matter placed in the focus of the glass.

A camera obscura may be made by placing a convex glass in a hole of a window shutter; then, if the room be darkened so that no light can enter but what comes through the glass, the pictures of all the objects (as fields, trees, buildings, men, cattle, &c.) on the outside, will be shewn in an inverted order, on a white paper, placed in the focus of the glass; and will afford a most beautiful and perfect piece of perspective or landscape of whatever is before the glass: especially if the sun shine upon the objects.

Portable cameras may be bought, to represent objects upon a paper laid flat, which is much more convenient for drawing. The sides of the box are made to fold and shut up like a book. To view the picture, the face is applied to an opening made for that purpose, and for tracing, the hand is put through a cloth sleeve, fastened to another opening.

A mahogany framed head with mirrors and lenses, suitable to the distance from about six to nine feet, is sometimes made to be applied to the roof of a house commanding an extensive prospect: the head being contrived to turn round in a horizontal direction. This instrument can, by any intelligent carpenter, be easily applied to the roof, to be put in and taken out occasionally. A round table, of about three feet in diameter, with a screw pillar to raise or depress its surface for adjusting it properly, according to the focal distance of the lens, or distances of the objects, will be necessary. Its surface should not be flat, but curved to the segment of a sphere, according to the focus of the lens and distance of the objects. The representation of distant objects in this manner will afford the highest pleasure and entertainment: and if objects in motion, such as carriages, horses, ships, &c. favourably illuminated by the sun, present themselves, their pictures will be formed in the most exquisite manner.

49. *To trace against the Light.*

Lay a piece of white paper over the face side of the drawing you wish to copy, and hold it against one of the panes of the window, or have a pane of glass put in a frame, and fitted up like a music-stand with a candle behind it. Lay your paper over the drawing, and you will find all the lines of the original distinctly through it, by this means you can easily trace them with a pen or black-lead pencil.

50. *To make Tracing-paper.*

Mix together equal parts of oil of turpentine and drying-oil, rub it with a rag evenly over some fan, or tissue paper. Let the paper dry for a day or two, and it will be fit for use. Lay this over the print or drawing you wish to copy, and you will see every line so distinctly through it, that you can go over them all with a black-lead pencil. If you wish to trace in ink, mix a little ox's gall with the ink, to make the paper take it, which it would not otherwise do from the oil.

51. *To make Camp-paper.*

Take some hard soap, which mix with lamp-black and water, to the consistence of a jelly; with this brush over one side of your paper, and let it dry.

When you use it, put it between two sheets of clean paper, with its black side downwards, with a pin, or stick having a sharp point, draw or write upon the clean paper; where the tracer has touched, there will be an impression upon the lowermost sheet of paper, as if it had been done with a pen. Camp-paper may be made of any colour, by mixing with the soap, black-lead, vermillion, &c.

52. *Stenciling.*

Lay the drawing you wish to copy over a sheet of paper, with a pin or needle prick all the outlines through both the papers. Then lay the clean paper with the holes made in it, upon the paper you wish to have the design tranferred to, and dust it over with a small muslin bag, of which powdered charcoal will penetrate through the holes, and leave a correct copy of the original upon the paper. This pricked paper will do again for any number of copies. It is very useful for ladies who work flowers upon muslin.

53. *To enlarge or contract Drawing by proportional Squares.*

Divide the margins of your original drawing with a pair of compasses into any number of equal parts, and rule lines with a black-lead pencil from side to side and from top to bottom. Then divide your paper into the same number of squares, either larger or less, as you enlarge or contract it. Place now your original before you, draw square by square the several parts, observing to make the parts of the figure you are drawing fall in the same part of the squares in the copy as it does in your original. To prevent mistakes, number the squares of both the original and copy. This is used by engravers.

To prevent the necessity of ruling across the original, which in some cases may injure it, take a pane of crown glass, and divide its sides into equal parts: from each division draw lines across the glass with lamp-black, ground with gum-water, which will divide the glass into squares; lay the glass upon the original you wish to copy, draw the same number of squares upon your paper, proceed to copy into each square on your paper what appears behind each corresponding square of the glass. Instead of a glass, an open frame, with threads stretched across, will answer the same purpose.

54. *The Pantagraph.*

This is an instrument by means of which we may copy, enlarge or reduce the the outlines of any print or drawing, and as a mathematical instrument, it is extremely useful for copying plans, maps, and other complicated figures.

SECTION VI.

OF THE PAINTING OF TRANSPARENCIES, &c.

55. The effect of this species of painting, which has lately become fashionable, not a modern invention, is pleasing, if managed with judgment, particularly in fire and moon-lights, where brilliancy of light and strength of shade are desirable. The great expence of stained glass, and the risk of keeping it secure, precludes its use in ornamenting rooms generally; but transparencies form a good substitute at a small expence.

The paper upon which you paint is fixed in a straining frame, to place it between you and the light, in the progress of your work. After tracing in your design, the colours are laid on in the usual method of stained drawings. When the tints are got in, you place your picture against the window, to strengthen the shadows, with Indian ink, or colours, as the effect requires, laying the colours sometimes on both sides of the paper, to give force of expression and depth of shade. The last touches for giving strength to shadows and forms, are done with ivory or lamp-black, prepared with gum-water, no pigment being so opaque and capable of giving strength and decision.

When the picture is finished, and perfectly dry, every part having received its depth of colour and brilliancy, you touch very carefully on both sides those parts designed to be brightest, as the moon and fire, and those parts requiring less brightness only on one side, with a varnish made by dissolving one part of gum mastic and one of Canada balsam, in two parts of rectified spirits of turpentine: or mastic varnish alone will answer the purpose. Be cautious, however, with the varnish, as it is apt to spread. When the varnish is dry, you tint the flame with red lead and gamboge, slightly tinging the smoke next the flame: the moon must not be tinted with colour.

Ground-glass is also a good substance to paint upon for transparencies. If you touch any part with varnish, that part will become transparent; and the rest may be painted in oil colours, thinned with spirits of turpentine, or varnish.

To paint upon linen or silk, it is first done over with isinglass size, and then painted with distemper or oil colours.

In transparencies, much depends upon the choice of the subject, none being so adapted to this species of effect as gloomy gothic ruins, antique towers, pointed turrets, and dark battlements, which finely contrast with "the pale moon." The moon's rays passing through ruined windows, half choaked with ivy, and fires amongst the clustering pillars and broken monuments of the choir, round which are figures of banditti, whose haggard faces catch the reflecting light: afford a peculiarity of effect, unequalled in any other species of painting. Internal views of cathedrals also, with stained glass windows, have a beautiful effect in transparencies.

The great point here is a happy coincidence between the subject and the effect produced. The light must not be too near the moon, as its glare would tend to injure her pale silver light; those parts which are not interesting must be kept in an undistinguishable gloom, and where the principal light is, they must be marked with precision. Groups of figures should be well contrasted; those in shadow crossing those in light, the opposition of light against shade giving effect to the whole.

56. *Crayon Painting.* This branch of the art, is a very inferior mode of painting, being only adapted for portraits, and of so perishable a nature, that the talents of eminent artists should never be employed in it. Those who are desirous of attempting it, may easily procure crayons ready prepared; and there is nothing particular in their use, that may not easily be acquired by persons acquainted with the principles of drawing.

57. *Glass Painting* is performed by staining it in a similar way to enamel painting, or by using opaque colours. The painters, as well as sculptors, of the Anglo-Saxon ages, were chiefly employed in working for the church, by drawing pictures of our Saviour, the Virgin Mary, the apostles, and other saints.

The first pictures used in this island, for the ornament of the Anglo-Saxon churches, were brought from Rome. But as the expence of bringing them all from the continent was sensibly felt, such of the English, particularly of the clergy, as had a taste for painting, applied to that art, in order to furnish their own churches with these admired ornaments; and some of these ingenious men were even acquainted with the art of painting on glass. The art was revived in our own country during the eighteenth century, and brought by British artists to as great, if not greater, perfection, than it ever before obtained. In effecting this revival, the celebrated *Jervas* was much distinguished. The finest specimens of his talents in painting on glass, are some copies from West, in the windows of St. George's Chapel at Windsor; and from Reynolds, at New College Chapel, Oxford.

58. *Mosaic Painting.* In the Chapel of St. John, belonging to the church of St. Roque, are preserved those monuments of Mosaic painting, which have so long been admired for simplicity and correctness of design; for the imagination displayed in their composition, and for the brilliancy and chasteness of their

execution. The subjects of these pictures, which have given celebrity to one of the most miserable looking buildings in Lisbon, are the Baptism of Christ by St. John, the Annunciation, and the Pentecost; in the two former, it is scarcely possible to do justice to the character and expression which is preserved in the different features and figures of which they are composed.

The modest enthusiasm of the Virgin, as she turns from the altar, where she has been praying, to receive the communication of the angel; the humility of Christ; and the awe and respect expressed by the face of St. John, which seems to speak that he is indeed baptizing one "Whose shoe's latchet he was not worthy to unloose," mixed with the high sense which he still retains of the sacred honour of being the "Messenger to prepare the way before him," merit the highest eulogium; while the disposition of the many figures which fill up the awkward subject of the Pentecost, and the variety of expression created upon different features by the same sentiment, excites nearly an equal degree of admiration. The *chiaro-scuro* of these paintings, and the unity of their colouring, is so well preserved, that one would not believe they were executed in Mosaic until, by the help of a ladder, he had a tangible ascertainment of the fact. They are the production of *Juste;* and are valued by the friars of Saint Roque at the enormous and exaggerated sum of three million *crusadas.* These friars bless themselves that the difficulty of the operation had retarded the intentions of the French to remove them before they were themselves obliged to quit the city. These paintings are ranged round a small Chapel of St. John, which occupies a recess in the great aisle of the church. The floor is also of Mosaic, and very finely executed. The altar beneath them is a magnificent composition of cornelian, lapis lazuli, amethyst, and alabaster, covered with a profusion of silver ornaments; but, magnificent as are these appendages, they can scarcely attract the eye of good taste from the pictures above them. This church possesses another splendid specimen of art in a fine bas-relief, representing a sacrifice of incense to the Lamb, executed in solid silver, upon a ground of lapis lazuli, the frame and cornice being also of solid silver; to this the monks have attached the value of three hundred thousand crowns; a sum, a little more in unison with probability than the other, but still greatly exaggerated, although the children and animal are of the size of nature.

59. *Distemper Painting.* This method of painting is performed with colours mixed with size or whites of eggs, or any glutinous substance, and laid on paper, linen, silk, board, or wall. If the colours are mixed with any glutinous or unctuous matter, instead of oil, it is said to be done in distemper. The cartoons at Windsor, and, in general, the scenes of theatres, are painted in this manner.

60. *Hydoric Painting,* was invented by M. Vincent, of Montpetit, but it is little known. It takes its name from two Greek words, signifying *oil* and *water,* both these liquids being employed in its execution. The advantages of this invention are, that the artist is enabled to give a high finish to small figures in oil—to add to the mellowness of oil-painting, the greatest beauty of water colours in miniature; and, to do this, so that it appears like a large picture viewed through a diminishing glass.

61. *Enamel Painting* is performed on plates of gold, silver, or copper, with certain metallic or earthy colours, melted by intense heat. Fine enamelling should only be practised on plates of gold. Nor must the plate be made flat; as in that case, the enamel cracks; but in the form of a watch-glass, and not too thick. The plate being well forged, the operation is begun by laying on a coat of white enamel on both sides, which prevents the metal from blistering, and this first layer serves for the ground of the other colours. The plate being prepared, the subject to be painted is drawn with red vitriol, mixed with oil of spike, marking all parts of the design lightly with a pencil. The colours, which are previously ground with water, extremely fine, in a mortar of agate, and mixed with oil of spike, are laid on. The painting is afterwards gently dried over a slow fire to evaporate the oil, and the colours melted to incorporate them with the enamel; making the plate red-hot. Any part of the painting effaced, is passed over again,

strengthening the shades and colour, committing it again to the fire; and this is repeated till the work is finished. This painting is employed in miniature.

Enamel possesses all the properties of glass, except its transparency. The basis of enamels is a pure crystal glass or frit, ground together with a fine calx of lead and tin, with the addition of a small proportion of the white salt of tartar. These form the principal ingredients of all enamels, which are made by adding pulverized colours, and thoroughly incorporating the whole in a furnace. Enamels are used to counterfeit or imitate precious stones as well as for painting; or by enamellers and artists working in gold, silver, and other metals. That used by jewellers is brought chiefly from Venice, or Holland, in cakes.

62. In *Encaustic Painting*, which was used by the ancients, wax was employed to give a gloss to the colours, and to preserve them from injury. The art was restored by Count Caylus, in 1753. The wood, or cloth, stretched on a frame, is rubbed over with bees' wax, being at the same time held over, or before, a fire, at such distance that the wax may gradually melt, while it is rubbed on. It must diffuse itself, penetrate the body, and fill the texture of the cloth, which, when cool, is fit to be used. But to make the colours, which are ground in water, adhere to the wax, the whole surface is first rubbed over with Spanish chalk, or white, the colours are then applied. When the picture is dry, it is put near the fire, by which the wax is melted, and the colours absorbed. They are not liable to fade or change; no damp or corrosive substance can affect them; they have no tendency to crack; and, if by accident they receive injury, they can be easily repaired.

63. *Fresco Painting* is performed on walls, and endures the weather. It is done with water-colours on fresh plaister; or a wall laid with mortar not dry. This sort of painting has a great advantage by its incorporating with the mortar, with which it dries, and is sometimes as durable as the stucco itself.

64. *Glass Painting* is performed by staining it in a

similar way to enamel painting, or by using opaque colours. The painters, as well as sculptors, of the Anglo-Saxon ages, were chiefly employed in working for the church, by drawing pictures of our Saviour, the Virgin Mary, the Apostles, and other Saints.

The first pictures used in this island, for the ornament of the Anglo-Saxon churches, were brought from Rome. But, as the expense of bringing them all from the continent, was sensibly felt, such of the English, particularly of the clergy, as had a taste for painting, applied to that art, in order to furnish their own churches with these admired ornaments; and some of these ingenious men were even acquainted with the art of painting on glass. The art was revived in our own country during the eighteenth century, and brought by British artists to as great, if not greater, perfection, than it ever before obtained. In effecting this revival, the celebrated *Jervas* was distinguished. The finest specimens of his talents in painting on glass, are some copies from West, in the windows of St. George's Chapel at Windsor; and from Reynolds, at New College Chapel, Oxford.

65. *Miniature Painting* is of very ancient date, and is practised either on vellum or ivory: the colours are prepared with water or gum. It is of all others the most delicate and tedious in its process, being performed wholly with the point of the pencil. It is only fitted for works of a small size, and must be viewed near. There are no subjects so well calculated for Miniatures, as the paintings of the old masters.

66. *Imitation of Pictures in Needle-work.* This is an art, which has, within a few years, surpassed the most renowned productions of former ages. The needle, in the hands of *Miss Linwood*, has become a formidable rival of the pencil; the pieces she has wrought far transcend all preceding attempts, both in number and excellence. Nor is less praise due to *Miss Thomson*, for her matchless exhibition of *paintings in wool.* But this is an art in which every lady now strives to excel. The subject is first painted upon a piece of cloth stretched on a frame, and then sewed with party-coloured worsted, till it acquires the tone of the drawing. But these pictures should always be hung so that the light may fall perpendi-

cularly, not slantingly, on them; else the stitches will appear, and render the surface disagreeable.

SECTION VII.

PAINTING IN OIL COLOURS.

The component parts of oil-painting are Invention, Composition, Design, Expression, Chiaroscuro, Colouring.

67. *Invention* consists in the choice of a subject within the scope of the art; the pitching upon the most striking and energetic moment of time for representation; and the discovery and selection of such objects, and incidental circumstances, as, combined together, may best develope the story, or augment the interest of the piece. The cartoons of Raffaelle now at Hampton Court, furnish a surprising example of genius and sagacity in this part of the art.

68. *Composition.* In composition, as regards the general distribution of objects, the painter contrives that the spectator may, at the first sight, be struck with the general character of the subject, and comprehend its design.

This effect is most readily produced by placing without violence or impropriety, essential figures in conspicuous places. Besides this distinctness in the general expression of the subject, the beauty of the composition depends on the variety, connection, and contrast, displayed in the distribution of objects; but these must be conformable to the nature of the subject.

69. *Design.* This part of the art is requisite even in making the first rough sketch, but it is when the artist exerts his utmost powers to give proportion, beauty of contour, grace and dignity of action and deportment to his figures, which constitute the perfection of *design,* that we can understand this third component part of painting.

The most perfect knowledge of form, however, is not the only branch of painting, termed design. The art of *fore-shortening*, whereby a limb or a figure, though occupying only a diminished space on the canvas, is rendered in appearance its full length, is an indispensible object of the artist's attainment.

70. *Expression.* The distinct exhibition of character in the general object of the work, or of sentiment in the characters or persons represented, requires the most consummate skill of the art, combined with a thorough knowledge of the passions, and the power of representing, justly, their various effects on the action and countenances of men.

Chiaro-scuro may be divided into three parts. In that case the first consists in connecting and combining the figures or objects of a composition in such masses of light and of shade, as are most pleasing to the eye, and best calculated for the just developement of the subject. 2. In assigning to each object the colour corresponding to its respective place in the group, and at the same time making it harmonize with the other colours of the picture. 3. In the judicious introduction of natural accidents, as stormy clouds occasioning partial gleams of light, sunshine, rainbows, fire-light, mist, &c., to strengthen the general effect and character of the work.

Colouring may be divided into two parts. 1. Strict attention must be given to that infinite variety of hues with which nature distinguishes her forms, agreeably to the degree and mixture of the rays of light which their surfaces reflect. 2. We must study the distribution, opposition, and accompaniment of various hues or tints to produce the most pleasing effect to the sight. As there are two sorts of objects, the natural or real, and the artificial or painted, so there are also two sorts of colours, the *natural*, or that which makes all the objects in nature visible to us, and the *artificial*, or that which, by a judicious mixture of simple colours, imitates those which are natural.

SECTION VIII.

OF COLOURS.

71. THE following may be considered a brief account of the different colours used in drawing and painting.

Red Colours are:

Lakes. This term denotes those colours which are formed by the combination of alumine, or the oxyd of tin, with the colouring matters of vegetables.

The lakes chiefly used are red colours, of different qualities, according to the basis and colouring matter employed; and are known by the names of *Carmine*, *Florence-lake*, and *Madder-lake.*

72. *Carmine*, a very rich bright crimson colour, stands well in water. For the preparation of carmine, take four ounces of finely-pulverized cochineal, which pour into four quarts of rain or distilled water, boiled previously in a *pewter* kettle, and boil the whole for six minutes; add, during the boiling, two drachms of pulverized crystals of tartar. Eight scruples of Roman alum, in powder, must be then added, and the whole be kept on the fire one minute longer.

As soon as the gross powder has subsided, and the decoction become clear, decant it into large cylindrical glasses covered over, and kept undisturbed till a fine powder is observed to have settled at the bottom. Then pour off the liquor from this powder, which is to be gradually dried. From the liquor still coloured, the rest of the colouring matter may be separated by the solution of tin, when it yields a carmine little inferior to the former.

73. *Florentine-lake*, the kind in general use, and known by the name of *lake* is used in water, and also in oil, but does not stand, it is a very beautiful colour at first, and there is no substitute that will completely answer the purposes of lake.

The best sort is prepared from the sediment of cochineal that remains in the kettle after making carmine, adding a small quantity of cochineal or Brazil-wood, and precipitating the colouring matter with a solution of tin.

74. *Madder-lake*, a colour lately brought into use is not so bright and rich a colour as the last-mentioned lakes. It has this valuable advantage, it stands much better, and answers many of the purposes of Florence-lake.

75. *Rose-lake* generally called *rose-pink*, is made by a basis of chalk, coloured by Brazil or Campeachy wood. It does not stand, and is only used for house-painting and paper-hanging.

76. *Vermillion* is a bright scarlet pigment, formed from sulphur and quicksilver, its brightness, and inclining to a crimson hue denotes its goodness. It is a very useful colour in oil, and stands well; but as a water-colour it is apt to turn black.

77. *Red-lead* or *minium*, is lead calcined till it acquires a red colour, by exposing it with a large surface to the fire. It is also made from *litharge*, a calx or oxyd of lead; but it is not so good as when made directly from metallic lead. This colour is apt to become black, both in water and oil. It is therefore seldom used but for very coarse purposes.

78. *Indian-red* is sometimes used instead of lake, and it might be useful, had it not the property of appearing stronger after some time. Never use it as a water colour. In oil this effect does not take place.

79. *Venetian-red* is a native red-ochre, rather inclining to the scarlet than the crimson hue; it differs little from the common Indian-red. It is fouler, and chiefly used by house-painters.

80. *Spanish-brown* an earthy substance found in the same state in which it is used; is nearly of the same colour as Venetian-red, but coarser. It is only used for the commonest purposes though it does not change.

81. *Light-red*, or *burnt-ochre*, is common yellow-ochre, heated red-hot, till the colour changes from a yellow to a red. It is an excellent colour, both in water and oil, having the quality of standing well.

82. *Red-chalk* the same substance used for drawing on paper, in the manner of a crayon, is very much like light-red, and is used instead of it, for some purposes. It stands well, and is used both in water and oil.

83. *Burnt Terra di Sienna* made by calcining raw terra di Sienna till it acquires a red colour, a very

rich tint, and much used in water and oil as it stands well in both.

Blue Colours.

84. *Ultramarine* is prepared from *lapis lazuli*, by calcining and washing it very clean. When genuine it is the brightest, the most beautiful of all colours, and stands well. It is much valued and used in oil, and means have been found to levigate it sufficiently for water-colour drawings.

85. *Ultramarine ashes*, the residuum after washing the lapis lazuli, in which a portion of the ultramarine still remains is very subject to be adulterated, and not so bright as ultramarine, being like that colour with a tint of red and white in it, yet when genuine it stands well.

86. *Prussian-blue* is iron combined with Prussian acid. It is made in the following manner:

Two parts of purified *potash* are intimately blended with three parts of dried and finely pulverized *bullock's-blood*. The mass is first calcined in a covered crucible, on a moderate fire, till no more smoke or flame appear; after this, it is brought to a complete, yet moderate ignition.

Or equal parts of potash and finely powdered coals, prepared from bones, horns, claws, &c. are mingled, and heated in a covered crucible to a moderate redness.

Either of these two calcined masses is, after cooling, lixivated with boiling-water, and the lixivium filtered. Nothing remains now but to make a solution of one part of green vitriol and two parts of alum; and to add to it, while yet hot, the above lixivium, little by little however, and to separate the greenish-blue precipitate, which then forms, by means of a filtre. If afterwards a slight quantity of diluted muriatic acid be affused upon this precipitate, it assumes a beautiful dark-blue colour. The operations is terminated by edulcorating and drying the pigment thus prepared.

Prussian-blue is an extremely beautiful colour when properly prepared, and stands tolerably well. Common Prussian-blue is apt to contain some iron, which causes it to turn greenish or olive.

87. *Verditer* a blue pigment, obtained by adding chalk or whitening to the solution of copper in aqua-

fortis is prepared by the refiners, who employ for this purpose the solution of copper, which they obtain in the process of parting, by precipitating silver from aquafortis by plates of copper.

Common verditer is made in Sheffield and Birmingham from the sulphate of copper. Verditer is only used for coarse purposes and chiefly by paper-stainers. It has been sometimes called SANDERS' blue, from the term *cendres-blues*, or blue-ashes.

88. *Indigo* extracted from a plant called the anil, that grows in the East and West-Indies is not so bright as Prussian-blue, but it has the advantage of being more durable. It is the blue generally used in drawings. It cannot be dissolved by water, but may by the sulphuric acid, it then forms SCOTT'S *liquid-blue*, used for colouring silk-stockings, &c.

89. *Smalt* is glass covered with cobalt, and ground to a fine powder. Its coarseness prevents its being used much for painting in oil or water. It is employed sometimes by strewing it upon a ground of oil-paint. It is also used in enamel-painting and the colouring of porcelain as it stands well.

Bice is smalt more finely levigated.

Yellow Colours.

90. *Indian-yellow*, the brightest of all yellows for water-colours, is not durable. It is said to be procured from the urine of the buffalo. In India, it is a common and cheap colour; the natives using it for colouring their calicoes, which they do without any mordant, so that the colour is washed out again when the cloth is dirty.

91. *King's-yellow*, is *orpiment* refined, a substance dug out of the earth, and consisting of sulphur joined to arsenic; it may also be prepared by subliming sulphur with arsenic. It is of a bright yellow, but does not stand well: it is a strong poison and great caution must be used in employing it.

92. *Naples-yellow* a very durable and bright yellow,

comes from Naples. It is prepared from lead and antimony.

93. *Yellow-ochre,* an earth naturally coloured by oxyd of iron is a cheap colour, and not very bright, but valuable, because it stands well. *Roman-ochre* is a superior yellow-ochre, of a rich tint.

94. *Dutch-pink* formed of chalk, coloured with the juice of French berries, or other vegetables affording a yellow colour, does not stand, and is chiefly used for common purposes.

95. *Gamboge,* a gum brought from the East Indies, dissolves readily in water, and is a fine serviceable yellow. It is used only in water.

96. *Masticot,* an oxyd of lead, prepared from calcining white-lead, is very little used, the colour not being bright.

97. *Gall-stones.* This is a hard substance, formed in the gall-bladders of oxen; or it may be obtained from the gall of animals. It is a rich colour, but does not stand.

98. *Raw Terra di Sienna,* a native ochreous earth brought from Italy, is a fine warm colour, and stands well.

99. *French-berries.* A liquor may be extracted from these, useful as a stain for coarse purposes; but it does not keep its colour.

100. *Turmeric-root* and *saffron,* may be used for similar purposes.

101. *Orange-lake* is the tinging parts of arnatto, precipitated together with the earth of alum. It does not stand.

102. *Brown-pink* is the tinging part of a vegetable substance precipitated upon the earth of alum. It is a rich greenish yellow, but does not stand.

Green Colours.

103. There are few colours so useful as green; and, it is therefore the practice with artists to form

their greens by the mixture of blue and yellow, and by varying these, a vast variety of green tints are obtained.

104. *Sap-green* is the concreted juice of the buck-thorn berries. It is used only in water, and is employed chiefly in flower-painting, colouring prints, &c.

105. *Verdigris* is an imperfect oxyd of copper, combined with a small portion of acetic, carbonic acid, and water.

It is prepared in large quantities, chiefly in France near Montpellier, by stratifying copper-plates with the husks of grapes, yet under various fermentation, which soon grow acid, and corrode the copper. After the plates have stood in this situation for a sufficient time, they are moistened with water, and exposed in heaps to the air. The verdigris is scraped off from their surface as it forms.

Verdigris is of a bluish-green colour, it has no body, does not stand, and is only used for coarse purposes; it answers best in varnishes.

106. *Distilled verdigris,* sometimes called crystils verdigris, is prepared from common verdigris, by dissolving it in vinegar. It is of very bright green, and is used chiefly for varnishes, and in colouring maps, &c.

Brown Colours.

107. *Bistre* is the finer part extracted from the soot of burnt wood. It is used alone for sketches in water-colours, being a transparent warm colour.

108. *Roman-bistre* is a very excellent but scarce kind of bistre imported from Rome.

109. *Cologne-earth,* a mineral substance of a dark-blackish brown colour, is a very useful pigment; what is generally sold in the shops for Cologne-earth is an artificial mixture.

110. *Raw-umbre,* a native ochreous earth, of a light-brown, stands well.

111. *Burnt-umbre* is only the last mentioned colour, calcined in the fire. It then acquires a rich deep brown, and is of great use, being a fine colour, that stands well.

112. *Asphaltum*, used in oil, is of a very rich deep brown. It is a transparent or glazing colour that will not work in water, but, when dissolved in turpentine, it becomes a useful substance for giving deep and spirited touches to drawings. The linens in which the Egyptians wrapped their mummies were dipped in Asphaltum.

White Colours.

113. *Flake-white* is an oxyd of lead, formed by corroding lead with vegetable acids, or vinegar.

114. *White-lead* is the same as flake-white, but of an inferior quality. It is the only white used in oil-painting, and is therefore a very useful colour; in water it always turns black.

115. *Egg-shell white*, and *oyster-shell white*, are only egg-shells or oyster-shells calcined; the animal gluten is thus destroyed, leaving the lime behind, which soon attracts the carbonic acid again from the atmosphere. Well washed *Spanish-white*, or *common whitening*, answers the same purpose.

116. *Permanent-white* is a white sold in the shops under this name, and it will not change; but great care must be employed in using it, as it is made from barytes, a deadly poison.

Black Colours.

117. *Lamp-black*, the soot of oil, collected after it is formed by burning, is very generally used, both in oil and water, and stands perfectly well. *Ivory-black*, the charcoal of ivory or bone, formed by giving them a great heat, while they are deprived of all access of air. It is used both in oil and water. *Blue-black*, the coal from burning vine-stalks in a close vessel, is like ivory black with a tint of blue.

CHAPTER III.

PRINTING, THE MAKING OF INK AND PAPER.

SECTION I.

STEREOTYPE PRINTING.

118. STEREOTYPE PRINTING was certainly anterior to printing by moveable types. The method of printing linen and paper for hangings, has been practised in the East from time immemorial. Printing from wooden blocks has been known in China for more than 1600 years. When a work is to be stereotyped, it is fairly transcribed upon a thin, transparent paper. Each leaf is then reversed, and fixed upon a smooth block of hard wood, where the characters are engraven in relief; there is therefore a separate block for each page. The Italians, Germans, Flemings, and Dutch, began to engrave on wood and copper, about the end of the fourteenth century, and inscriptions in relief upon monuments and altars, in cloisters, and over church porches, became models for block-printing; and the letters upon painted windows, strongly resemble those in books of images.

The invention of cards in France, in the reign of Charles the Wise, about the year 1376, was an intermediate step. They were soon introduced into Spain, Italy, Germany, and England. At first the cards were painted; afterwards, about the year 1400, a method was devised of printing them from blocks, and to this we may trace the art of printing. The next step resulted the books of images, printed from wooden blocks; one side of the leaf only was impressed, the corresponding text was placed below, at the side, or it issued from the mouth of the figure; the idea of stereotype printing is, therefore, not of modern origin.

Towards the close of the seventeenth century, this art, therefore, was practised in Holland. William Ged, of Edinburgh, in the year 1725 made the first use of this art in Britain; but, owing to some defect in the plan, or want of skill in its execution, the invention attracted little notice.

In 1782, my friend Mr. Tilloch revived, or rather re-discovered this art; he was ignorant of Ged's contrivance long after he had announced his own. In the subsequent year, he took out a patent for it, in conjunction with Foulis, of Glasgow.

About 1789, M. Didot, of Paris, stereotyped his logarithmic tables; and several improvements, which he introduced, rendered his mode both convenient and useful. The French, who would be foremost in every thing, claim the merit of this invention. The name stereotype seems first to have been employed by M. Didot; it is derived from στερεος, solidus, and τυπος, typus, denoting that the types were soldered, or otherwise connected together; but does it follow that the French have the honour of this invention?

After Tilloch had given up the prosecution of this art, Wilson, a printer, of London, engaged with the late Earl Stanhope, to bring it to perfection, and eventually established it in this country. After two years application, the stereotype art was, with the approbation of Earl Stanhope, offered to the University of Cambridge, and accepted by them [1804]. Their bibles, testaments, and prayer-books being printed in this manner, and the plan has been followed by the Bible Society, and other persons, for printing bibles, dictionaries, grammars, &c. &c. The stereotype method has the advantage of common printing, wherein no alteration, as to plan or size, takes place. But for general purposes in the art, the method by moveable types is incontestably the best.

The method of Stereotype Printing is this: A page is composed, in the common way, with moveable types; and when it has been corrected, a mould, or impression, is then taken off the page with plaster of Paris, from which one in metal is cast. Ged's plan, consisted only in setting up the moveable types, and soldering them together, to form a permanent page. The principal objects of this invention are correctness and economy.

Letter-press Printing.

119. Printing by letter-press, the most curious branch of the art, demands particular notice, as three cities in Europe, Haerlem, Strasbourg, and Mentz, claim the honour of this invention. A person named Guttemberg appears to have been the inventor of the art of printing by moveable types; he began the art at Strasbourg, and perfected it at Mentz.

The evidence in favour of Guttemberg appears decisive: we shall not enter into any examination of the claims advanced by John Fust, of Mentz; John Mental, of Strasbourg; and L. John Koster, of Haerlem. When Mentz was taken by Adolphus, Count of Nassau, in 1462, Fust, and Schoeffer his servant and son-in-law, suffered materially with their fellow townsmen. Their workmen dispersed to seek their fortunes, and thus the art was diffused over Europe. When it was first established at Paris, the transcribers of books, finding their trade injured, presented a memorial of complaint to the parliament, and that tribunal, as superstitious as the people, who took the printers for conjurors, had their books seized and confiscated. But Louis XI. forbade the parliament to take any farther cognizance of the affair, and restored their property to the printers.

The art of printing now spread itself with astonishing rapidity, over a great part of Europe. It was practised at Rome in 1467, and the year following Thomas Bouchier, Archbishop of Canterbury, introduced it into England. But both the origin and the history of the first introduction of the art of printing into this country, are involved in doubt and obscurity.

Fine printing was first introduced by Baskerville, and the numerous editions which he published of various important works, but particularly of the Latin classics, are well known. They were printed in a style surpassing every thing of the kind which had been issued from the press; and the peculiar excellence attached to the types of Baskerville, and the consequent celebrity he obtained, gave a stimulus to the exertions, and have called forth the emulation of Bensley, Bulmer, Davison, Whittingham, M'Creery, Ballantyne, and Ramsey, who have produced the finest specimens of typography that are to be found in Europe.

120. Types are the letters of the alphabet, &c. divided into LARGE CAPITALS, SMALL CAPITALS, and *Italic.* The letters most frequently used are: Black Letter, Great Primer, English, Pica, Small Pica, Long Primer, Bourgeois, Brevier, Minion, Nonpareil, Pearl, and Diamond.

BLACK LETTER.

Mode of Letter-press Printing.

GREAT PRIMER.

The workmen employed in this

art, are compositors and pressmen.

ENGLISH.

The compositors range and dispose the letters into words, lines, pages, &c.

PICA.

The pressmen are, properly speaking, the printers, as they take off the impression from the letters, that have been prepared by the compositors.

SMALL PICA.

The compositor distributes each kind of type or sort, by itself, into small cells, made in two wooden frames, called the cases; the upper-case, and the lower-case. There are ninety-eight cells in the upper-case; and fifty-four in the lower-case.

LONG PRIMER.

The upper-case contains two alphabets of capitals, viz. large, or full capitals, and small capitals. They also contain certain cells for the numerical figures, 1, 2, 3, &c.; the accented letters, á, ç, &c.; the characters used in references to notes, *, †, ‡, ‖, &c.; and one cell, being a middle one in the bottom row, for the small letter k. The capitals in this case are disposed alphabetically.

BOURGEOIS.

The lower-case is appropriated to the small letters, the double letters, the points, parentheses, spaces, and quadrats.

BREVIER.

The boxes of the lower-case are of different sizes. In the largest are letters most in use; but the arrangement is not alphabetical; for those letters which are oftenest wanted, are placed nearest the compositor's hand.

MINION.

There is nothing on the outside of the boxes to denote the letters which they respectively contain. It is therefore curious to observe the compositor's dexterity in finding and taking up the letters, as he wants them, from the different cells.

NONPAREIL.

The instrument in which the letters are set, is called a composing stick. It consists of an oblong plate of brass or iron; on the side of which arises a ledge, which runs the whole length of the plate, and serves to support the letters.

Along this ledge a screw passes to lengthen or shorten the line, by moving the sliders farther from, or nearer to, the shorter ledge at the end of the composing-stick. When marginal notes are required, the two sliding pieces are opened to a proper distance from each other. Before the compositor begins to compose, he puts a thin slip of brass plate, called a rule, cut to the length of the line, and of the same height as the letter, in the composing-stick, parallel with the ledge, against which the letters are intended to bear.

The compositor being thus furnished with an instrument suited to hold the letters as they are arranged into words, lines, &c. he places his copy on the upper-case, just before him, and holding the stick in his left hand, his thumb being over the slider, with the right hand he takes up the letters, spaces, &c. one by one, and places them against the rule, while he supports them with his left thumb, by pressing them against the slider, the other hand being employed in setting in other letters.

Having in this manner composed a line, the workman takes the brass rule from behind it, and places it before the letters, and proceeds to compose another line in the same manner. Before he removes the rule, he notices whether the line ends with a word, or a syllable of a word, including the hyphen that denotes the division, when a word is divided into syllables.

If the words exactly fill the measure, he has nothing more to do with that line, but proceeds with the next. Should the measure not be entirely filled at the ending of a word or syllable, he puts in more spaces, diminishing the distances between the words, until the measure is full; this operation is called justifying. Much depends upon exactness in justifying; and with expert compositors the lines are neither too closely wedged into the composing stick, nor yet loose and uneven.

The spaces are pieces of metal, of various thicknesses, exactly shaped like the shanks of the letters, to regulate the distances between the words.

When the composing-stick has been filled with ten or twelve lines, the compositor empties it on to a board called a galley. This board is of an oblong shape, with a ledge on two sides, and a groove to admit a false bottom. When the compositor has composed a page, he ties it up with a piece of pack-thread, and removes it from the galley, to the imposing-stone, or to a shelf under his cases, where it is safe. In this manner he proceeds until he has composed as many pages as make a sheet, or, in some instances, a half.sheet. He then proceeds to arrange the pages on the imposing-stone, a large oblong stone, about five or six inches thick.

The pages are so arranged that when printed they may follow each other regularly. Care and ingenuity are requisite in imposing a sheet or half-sheet, particularly of works in sizes less than folio or quarto. Having disposed the pages in order on the imposing-stone, the compositor dresses his chases. The chase is a rectangular iron frame, having two cross pieces, of the same metal, called a long and short cross, mortised at each end so as to be taken out occasionally; and by the different situations of these crosses the chase is fitted for folio, quarto, octavo pages, &c.

To dress the chase, the compositor has, what he terms, a set of furniture. The furniture consists of small slips of wood of different sizes. The chase is laid over the pages: part of the furniture, called gutter-sticks, are placed between the respective pages, and another part of the furniture called reglets, are placed along the sides of the crosses of the chase. The reglets are of such a thickness as will let the book have proper margins after it is bound. After dressing the inside of the pages, the compositor does the same with their outsides, by putting side-sticks and foot-sticks to them.

The pages placed at proper distances, now are all untied, and fastened together by small quoins or wooden wedges. These small wedges being firmly driven up the sides and feet of the pages, by a mallet, and a piece of iron or hard wood called a shooting-stick, the letters are all fastened together. The work in this condition is called a form, prepared for the pressman, who lays it on the press, for the purpose of *pulling a proof.* When a proof is pulled (printed), the form is washed with a brush, dipped in a ley, of pearl-ash and water. The form for the opposite page undergoes the same process; the proof and forms are then delivered to the compositor, to be carefully read and corrected before they are finally worked off; the proof, with the copy from which it has been composed, is now given to the reader, or corrector, whose business it is to read over the whole proof two or three times with great care and attention, marking in the margin of every page such errata as he shall observe.

The sheet is again put into the hands of the compositor, who corrects in the forms what has been marked for correction in the proof. He then unlocks one form on the imposing-stone, by loosening the wedges which bound the pages together.

He casts his eye over one page of the proof, noticing what letters are required, and having gathered as many from the cases, he takes a sharp pointed steel bodkin in his right hand. Placing the point of the bodkin at one end of the line, and the fore-finger of his left hand against the other, he raises the whole line to have a clear view of the spacing, and he then changes the letters, and alters his spaces before he drops the line.

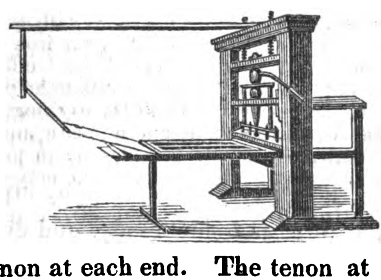
Another proof is now pulled, to be again put into the hands of the reader, or sent to the author for examination, and it being read and corrected as before, a revise is pulled, to see whether all the errors marked in the last proof are properly corrected; the forms are given to the pressman, to work them off when they are perfectly corrected; four things are required in press work; paper, ink, balls, and a press.

The paper is prepared for use by being dipped, a few sheets at a time, in water, and afterwards laid in a heap, to make the water penetrate every sheet equally, and a thick deal board is laid upon the heap, to bear heavy weights, according to the size of the heap. The paper is wetted before printed on, that it may be made sufficiently soft to adhere closely to the surface of the letter, take a proper quantity of ink, and receive a fair and clear impression. Were it not wet, its stiff and harsh nature would injure the face of the letters.

The manufacture of good common ink is still but imperfectly understood; or at all events, few printers will use it. That used in fine printing, is in a great degree free from that offensive brown cast observable in books printed with common ink; a wretched stuff fit only for newspapers and other ephemeral productions.

The balls used in laying the ink on the forms, are made of skin, stuffed with wool or hair, with handles. One skin generally makes two balls. The balls, when completed, have the shape and appearance of a large mallet, used by stone-masons, except that their surface is broader and rounder. The use of balls, however, is now generally superseded by rollers (the invention of Mr. Applegarth), covered with a composition which has the property of distributing the ink more evenly, and is less liable to collect the dirt, than the skin of which the balls were made.

The press is a curious and complex machine, to describe which is difficult: it consists of two upright beams, called cheeks; about six feet long, eight inches and a half broad, and five inches thick,



with a tenon at each end. The tenon at the upper end of the cheek enters the cap within half an inch of the top. The cap is a piece of timber, three feet long, eleven inches wide, and four inches thick. The lower tenon of the cheek enters the feet, which is a square wooden frame both thick and strong.

The head is moveable, but sustained by two iron bolts that pass through the cap. The spindle, an upright piece of iron, pointed with steel, having a male screw which goes about four inches into the female one in the head, is so contrived that when the pressman pulls a lever, attached to it, the pointed end works in a steel pan supplied with oil, and fixed to an iron plate let into the top of a broad thick piece of mahogany, with a perfectly plane surface, called a platten. This platten rises and falls as the pressman pulls or lets go the lever. When the platten falls, it presses upon a blanket, that covers the paper, when it lies upon the form, from which the impression is to be taken.

The form is laid upon a broad flat stone, let into a wooden frame, called the coffin, that moves backwards or forwards, by the turning of a wince. At the end of the coffin are three frames; two of which are called tympans, and the remaining one a frisket. The tympans are square, made of three slips of thin wood, and at the top a piece of iron, still thinner; the outer tympan is fastened with hinges to the coffin; both are covered with parchment, and between them are placed blankets, to take off the impression of the letters upon the paper.

The frisket, a square frame of thin iron, fastened to the hinges of the tympan, is covered with paper cut in the necessary places, that the sheet, put between the frisket and the outer tympan, may receive the ink, and that nothing may hurt the margins. To regulate the margins, a sheet of paper is fastened upon this tympan, called the tympan sheet. This ought to be changed when it becomes wet with the paper to be printed on. On each side is fixed an iron point, that makes two holes in the sheet. These holes are to be placed on the same points when the impression is to be made on the other side. In preparing the press for working, or, as it is technically called, making ready a form, care and attention are requisite that the printed sheets may be in proper register, that is to say, that the lines on one side may exactly fall upon the backs of the other.

When the form is made ready, and every thing prepared for working, one man beats the letters with the inked balls, another places a sheet of paper on the tympan sheet, turns down the frisket upon it to keep the paper clean, and prevent its slipping, brings the tympan upon the form, and turning the wince, by which the carriage, holding the coffin, stone, and form, is moved, he brings the form and stone under the platten.

He then pulls with the lever, by which the platten presses the blankets and paper close upon the letter, and thus half the form is printed. He then eases the bar, draws the form still forward, gives a second pull, and letting go the bar, turns back the carriage, &c. He next raises the tympans and frisket, takes out the printed sheet and lays on a fresh one; this is repeated till he has taken off the impression upon the number of sheets of which the edition consists. One side of every sheet being thus printed, the form for the other side is laid on the press, and worked off in the same manner.

The common press, though constructed on the true principles of mechanism, does not produce an adequate impression from heavy works in small letter, without great labour and attention. An accession of power is gained, with a diminution of labour by the iron press, invented by the late Earl Stanhope.

It is a compact and curious machine, altogether worthy the genius of the nobleman who first constructed it. This press is superior to the common press, and produces a more clear and strong impression, especially from light forms.

Logographic Printing.

121. In 1784 a patent was granted to Henry Johnson, for a new mode of printing, termed Logography. This method consists in employing types expressive of whole words, instead of those corresponding to single letters. By this plan, it is contended, that the compositor is less liable to error; the type of each word being taken up with as much facility as a letter; and when a sheet is printed off, such types may be more easily distributed.

True:—the number of types in logography it is also asserted does not exceed that required by the common mode of printing; granted. But the expediency of this contrivance has been doubted, and the inconveniences attending it have prevented its adoption. Might not much greater advantages be derived from casting syllables instead of whole words? the former occur more frequently. Might they not be so arranged as to follow in alphabetical order, in proportion to their recurrence?

Fac-simile Printing.

122. Fac-simile printing is the art of forming types precisely to resemble the manuscript intended to be copied. The first approach to this method of printing, was the Medicean Virgil, printed at Florence in 1741. This, though an approximation, was no fac-simile printing, the resemblance of the manuscript was not complete.

The first great work of this kind, which was executed with taste and correctness, was the New Testament of the Alexandrian M.S. in the British Museum, published by Dr. Woide, in 1786, and since that time some works of considerable extent have been published on the same plan.

Lithography; or the art of Printing from Stone.

123. This novel process was invented by a performer of the Opera-house in Vienna; and it has now arrived at such perfection throughout Europe as to be found pre-eminently useful in the multiplication of copies, or fac-similes of manuscripts, drawings, &c. All kinds of close calcareous stone of an even and fine grain, which are capable of taking a good polish with pumice-stone, and having the quality of absorbing water, may be used for lithography.

Ink.

124. To compose the ink, heat a glazed earthen vessel over the fire: when it is hot, introduce one part by weight, of white Marseilles soap, and as much mastic in grains: melt these ingredients and mix them carefully; then incorporate five parts by weight of shell lac, and continue to stir it: to mix the whole, drop in by degrees a solution of one part of caustic alkali in five times its bulk of water. Make

this addition with caution; because, if the ley is added all at once, the liquor would froth up and run over the edges of the vessel.

When the mixture of these substances is accomplished by a moderate heat and frequent stirring, a necessary quantity of lamp-black is to be added; and immediately after put in a sufficient quantity of water to make the ink liquid and proper for writing.

125. *Drawing.*

This ink is used to draw on the stone in the same manner as on paper, either with a pen or pencil; when the drawing on the stone is quite dry, and an impression is desired, the surface of the stone is wetted with a solution of nitric acid, in the proportion of fifty to one of water; this must be done with a soft sponge, taking care not to make a friction on the drawing.

The wetting must be repeated as soon as the stone appears dry; it makes an effervescence, and when that ceases the stone is to be carefully and gently rinced with clean water.

126. *Printing.*

While the stone is still moist, it should be passed over with the printer's ball charged with ink, which will only adhere to those parts which are not wetted. A sheet of paper properly prepared for printing is then spread on the stone, and the whole submitted to the press, or passed through a roller.

To preserve the drawing on the stone from dust, if not in immediate use, a solution of gum arabic is passed over it, which can be removed by a little water when the stone is wanted again.

Instead of ink, they sometimes make use of chalk crayons for drawing upon the stone or upon paper, from which a counter-proof is taken upon the stone. The crayons are made in the following manner.

Three parts of soap, two parts of tallow, and one part of wax, are all dissolved together in an earthen vessel. When all is well mixed, a sufficient portion of lamp-black, called Frankfort black, will give it an intense colour: the mixture is poured into moulds, where it must remain till quite cold, when it will become consistent, and proper to be used as chalk pencils.

These effects, produced by tracing or drawing on the stone with a greasy or resinous substance, are the simple results of affinities of which there are three causes:—

1. The facility with which this compact calcareous stone imbibes moisture, without its retaining it in too great a degree.

2. The penetrating power, or rather the strong adherence of greasy or resinous bodies to these stones.

3. The affinity of resins and grease for all bodies of the same nature, and the antipathy of these substances to water, and all moist bodies.

From these three principles arise the same number of consequences:

First, a stroke made with a pencil or greasy ink on the stone, will adhere so strongly thereto, as to require some mechanical means to remove it.

Second, all parts of the stone, that are not covered by a coat of grease, will receive, absorb, and retain water.

Third, if a layer of coloured greasy substance, be passed over the stone thus prepared, it will only adhere to those lines formed by the greasy ink, whilst it will be rejected by those parts that are moistened with water only.

In a word, the lythographical process depends on these two points, that the stone saturated with water, should resist the ink; and that this same stone, oiled or greased, should resist the water and take up the ink; thus, by applying and pressing a sheet of paper on the stone, the greasy and resinous coloured lines will alone be transmitted on the paper, shewing a counter-proof impression of that which is drawn on the stone.—For this purpose the stone must first be rendered capable of imbibing water, and at the same time of receiving with facility all greasy or resinous bodies.

The former object can be effected by an acid which will corrode the stone, and take off its fine polish, and, make it capable of receiving the water.

Any greasy substance is capable of giving impression upon stone, whether the lines be made with a pencil or with greasy ink; or otherwise the ground of a drawing may be covered with a black greasy mixture, leaving the lines in white.

SECTION II.

INK MAKING—BOOK-BINDING.

127. Inks are fluid compounds, designed to form characters, or figures, on paper, parchment, or such other substance as may be fit to receive them.

There are two principal kinds of ink, writing, and printing ink.

To make writing ink. To an infusion of gall-nuts add some solution of sulphate of iron (green copperas) and a very dark-blue precipitate will take place.

This precipitate is the gallic acid of the galls united to the iron of the green vitriol, forming gallat of iron. This is the basis of writing ink, add a little gum-arabic; or, take eight ounces of Aleppo-galls, in coarse powder; four ounces of logwood, in thin chips; four ounces of sulphate of iron (green copperas;) three ounces of gum-arabic, in powder; one ounce of sulphate of copper (blue vitriol;) and one ounce of sugar-candy. Boil the galls and logwood together in twelve pounds of water for one hour, or till half the liquid has been evaporated. Strain the decoction through a hair sieve, or linen cloth, and then add the other ingredients. Stir the mixture till the whole is dissolved, more especially the gum; after which, leave it to subside for twenty-four hours. Then decant the ink, and preserve it in bottles of glass or stone-ware well corked, or the following Formula for the preparation of good writing ink may be used: for writing ink the following proportions of materials are deemed best; three ounces of finely bruised galls; one ounce of green vitriol; one ounce of logwood shavings; one ounce of gum arabic; half an ounce of bruised cloves; one pint of distilled vinegar; one pint of distilled water. These materials are to be put together in a bottle, and set in a warm place fourteen days, being well shaken every day. The coarser parts being allowed to subside, the ink is poured off; and its quality is materially improved by dissolving a stick of Indian ink and ten grains of corrosive sublimate in each quart: an ounce of brown sugar may also be added if the ink is intended to be used in the copying press.

To make red writing ink: take a quarter of a pound of the raspings of Brazil wood, and infuse it two or three days in vinegar. Boil the infusion for an hour over a gentle fire, and filter it while hot. Put it again over the fire, and dissolve in it, first, half an ounce of gum arabic, and then of alum and white sugar, each half an ounce.

Printing ink. Printers' ink is composed of lamp-black and linseed or suet oil boiled, so as to acquire consistence and tenacity. The obtaining of good lamp-black appears to be the chief difficulty in making this ink.

The ink used by copper-plate printers, differs from the last only in that the oil is not so much boiled, and the using of Frankfort black.

128. *Sympathetic Inks.*

Sympathetic inks are such as do not appear after they are written with, but may be made apparent by certain means to be used for this purpose. A variety of substances have been used for this purpose. We shall describe the chief of them.

1. Dissolve sugar of lead in water, write with the solution, and when dry, no writing will be visible. When you want to make it appear, wet the paper with a solution of alkaline sulphuret, and the letters will immediately appear of a brown colour. Even the vapours of these solutions will render the writing apparent.

2. Write with a solution of gold in *acqua regia*, let the paper dry gently in the shade, and nothing will appear; but draw over it a sponge wetted with a solution of tin in *acqua regia*, and the writing will appear of a purple colour.

3. Write with an infusion of galls, and when you wish the writing to appear, dip it into a solution of green vitriol; the letters will appear black.

4. Write with diluted sulphuric acid, and nothing will be visible. To render it apparent, hold it to the fire, and the letters will instantly become black.

5. The juice of lemons, or of onions, a solution of sal ammoniac, green vitriol, &c. answers the same purpose.

6. Green sympathetic ink is made by dissolving cobalt in nitro muriatic acid: write with the solution, and the letters will be invisible till held to the fire, when they will appear green, but disappear completely again when removed into

the cold. In this manner they may be made to appear and disappear at pleasure.

A very pleasant experiment of this kind, is to make a drawing, representing a winter scene, in which the trees appear void of leaves, then put the leaves on with this sympathetic ink; and upon holding the drawing near to the fire, the leaves will begin to appear in all the verdure of spring, and surprise those who are not in the secret.

Blue sympathetic ink is made by dissolving cobalt in nitric acid; precipitate the cobalt by potash; dissolve this precipitated oxyd of cobalt in acetic acid, and add to the solution one-eighth of common salt. This will form a sympathetic ink, which, when cold, will be invisible, but will appear blue by the heat of the fire.

129. *Book-binding.* The leaves being accurately folded are beaten with a hammer on a stone to make them smooth and lie close; they are then put into a press, and sewed on boards, after which the backs are glued, and the bands opened and scraped to fix the pasteboard covers; the back is rounded with a hammer, and the book fixed in a press, between two boards. Holes are then made for fixing the pasteboards to the volume, which is pressed a third time.

It is then put to the cutting-press, between two boards, one lying even with the press for the knife to run upon, the other above for the knife to run against; after this operation the pasteboards are squared: the leaves sprinkled, by dipping a brush in vermillion and sap green, holding the brush in one hand and spreading the hair with the other. The leather covers are moistened, cut to the size of the book, smeared with paste, and afterwards stretched over the pasteboard on the outside, and doubled within, after having taken off the four angles, and indented and platted the cover at the head-band. The book is now covered and bound between two bands, and set to dry. It is afterwards washed with paste and water, and then sprinkled with a brush; if marbling be required, on the leathern covers, the spots are made by the addition of vitriol. The book is glazed with the white of an egg, and polished with a hot iron: the letters and ornaments are made with gilding tools, or brass cylinders, rolled along by a handle. To apply the gold, the leather is glazed with whites of eggs diluted with water, when nearly dry the gold leaf is laid on, and the leathers, or ornaments, are made with tools, heated in a charcoal fire. For preserving books from the depredation of worms, mineral salts, (alum, and vitriol,) should be mixed in the paste used by bookbinders, and instead of flour, the paste should be made of starch. A little pulverized alum is also efficacious if strewed between the book and its cover, and upon the shelves of the library.

CHAPTER IV.

SCULPTURE.

SECTION I.

TERMS EXPLAINED.

130. SCULPTURE necessarily comes in to be considered in conjunction with the branches of the fine arts we are now enumerating. In sculpture moulding and casting there are several terms which we will here explain.

Bust denotes the figure or portrait of a person in relievo, shewing only the head, shoulders, and breast. Busts are commonly placed on a pedestal.

Casting, among sculptors, implies the taking of casts and impressions of figures, busts, medals, &c. The method of taking casts of figures, is generally by the use of plaster of Paris, that is, alabaster calcined by a gentle heat. This substance is preferable to others, because it is easily reduced to a powder by heat, and by being moistened with water, is capable of taking any form when impressed on moulds, and when dry is capable of great hardness, and will continue to retain it. Hence it is used for moulds themselves; and for casts to receive impressions from moulds. Parchment-size is mixed with water and plaster to render it more hard and tenacious.

Creux, a term much used by the French, signifies a hollow cavity or pit from which something has been scooped out. It thence denotes that kind of sculpture and graving in which the lines are drawn within the *plane of the plate*: it is thus the opposite of *relievo*.

Relievo, which applies to that kind of sculpture, whereby figures receive a projection from the plane they are designed on; and this term is indifferently applied to works executed with the chisel, or modelled in clay, or cut in plaster or metal.

In *Alto-relievo*, the figure formed after nature projects as in the life.

In *Mezzo-relievo*, that is half relief, the figure rises from the ground in such a manner as to appear divided by it.

In *Basso-relievo*, (low relief) the work is but little raised from the ground as in a *Waterloo* medal—a shilling, or any piece of coin. In masonry, you will see this prominently in historical subjects, as the *column* in the *Place Vendome* at Paris in festoons, foliages, and other ornaments of friezes as that of the *India House*, Leadenhall-street, and Covent Garden Theatre.

SECTION II.

ANCIENT SCULPTURE.

131. According to the most esteemed writers on sculpture this art may be divided into the Egyptian, the Phenician, the Persian, the Etrurian, the Grecian, the Roman, and modern sculpture.

132. *Egyptian Sculpture* was early cultivated, but many causes obstructed its progress. The persons of the Egyptians possessed nothing of elegance or symmetry, or the graces of form; and, of consequence, they had no perfect standard by which they could model

their taste. Being prevented by their laws from introducing any innovations which might militate against the practice of their ancestors, their statues were formed in the same stiff attitude, the arms hanging perpendicularly down the sides.

The Egyptian statues formed by the chisel were polished with great care and executed in *granite* or *basaltes*, stones of the hardest texture: we cannot sufficiently admire the excessive labour, and the indefatigable perseverance of the artist. The *eye* was of ten different materials from the rest of the statue, and not unfrequently composed of a precious stone, or metal. The largest and most beautiful diamond hitherto known, which was in the possession of the late Empress of Russia, formed one of the eyes of a famous statue deposited in the temple of Brama. The Egyptian statues still remaining, are composed of wood, or baked earth; and the latter are cased in green enamel.

133. *Phenician Sculpture.* The character and situations of the Phenicians were favourable to the cultivation of statuary. In their own persons they possessed beautiful models, and their industrious character qualified them to attain perfection in every art, their temples shone with statues and columns of gold, and a profusion of emeralds was every where scattered.

134. *Persian Sculpture.* It was not necessary to raise statues to great men in Persia, and statuary could not flourish. The Persian dress, consists of long flowing robes, which conceal the whole person, and prevented them from attending to the beauties of sculpture. Their religion presents another obstacle to their improvement in this art, and takes away those motives which alone could give it dignity and value. They were taught to worship the Divinity in the emblem of fire, and that it was impious to represent him under a human form.

135. *Grecian Sculpture.* The first representations of the gods of Greece were round stones, placed upon cubes or pillars, these stones were afterwards roughly formed, to give them the appearance of a head. These

representations were called *Hermes*, from a word which signified a stone. The superiority of the Greeks in sculpture may be ascribed to various causes. Their serene air and happy climate contributed to unfold and expand the human body, in all the symmetry of muscular strength, and all the delicacies of female beauty. But their consummate excellence in sculpture, may be accounted for chiefly from their having the human figure often before their eyes, quite naked, and in all its various attitudes, both in the palæstra or places of exercise, and in their public games. The grandeur of the antique statues is united with a perfect simplicity, because the attitude is not the result of an *artificial* disposition of the figure, as in the modern academies, but is nature unrestrained. In the statue of the *Dying Gladiator*, when we observe the relaxation of the muscles, and the visible failure of strength and life, we cannot doubt that nature was the sculptor's immediate model of imitation. And this nature was in reality superior to what is now seen in the ordinary race of men. The constant practice of gymnastic exercises gave a fine conformation of body, sought for in vain in modern fashion. In addition to these favourable circumstances, the productions of art were estimated and rewarded by the greatest sages in the general assembly of Greece, and the sculptor, who had executed his work with ability and taste, obtained immortality.

"The Grecian sculptors, who represented with such success the most perfect beauty of the human form, were not regardless of the drapery of their statues. They cloathed their figures in the most proper habiliments, which they wrought into that shape best calculated to give effect to the design. The first material employed in statuary was clay; and the ancients made works in plaster. Their works of *ivory* and *silver* were generally small; sometimes, however, they were of a prodigious size. The colossal Minerva of Phidias, which was composed of these materials, was twenty-six cubits high. The quantity of ivory necessary to a colossal statue is beyond conception, and the statue of *Jupiter Olympus*, which was fifty-four feet high, might consume the teeth of 300 elephants.

The Greeks generally hewed their marble statues out of one block, though they sometimes worked the head and arms separately. When the statue had received its perfect figure, they polished it with pumice-stone, and again carefully retouched every part with the chisel. The ancients made statues of basalt and alabaster. When they employed porphyry, the head and extremities were usually of marble.

Expression, gesture, and attitude, the peculiar characteristics of the Grecian statues, are instanced in three of the most celebrated examples of ancient sculpture.

(1.) The *Apollo Belvidere* represents the god in a fit of rage against the serpent Python, which he kills at a blow. In the mouth, we discover an air of satisfaction, bordering on contempt; but this light dissonance disturbs not the divine harmony of the whole. This faint tint of inquietude is absorbed in an inexhaustible fund of energy and tranquillity, a character perfectly suitable to a god victorious by his own energy alone.

(2.) The group of *Niobe and her Daughters*, against whom Diana has discharged her fatal arrows, are exhibited in that state of stupefaction, which takes place when the prospect of death deprives the soul of all sensibility.

(3.) The *Laocoon*, and his two sons, entwined by serpents. While Laocoon was sacrificing to Apollo, two enormous serpents issued from the sea, and attacked his two sons, standing by the altar, the father attempted to defend them, the serpents twined them in their complicated wreaths. The sculptor has here exhibited the most agonizing pain that can affect the muscles, the nerves, and the veins. The sufferings of the body, and the elevation of the soul, are expressed in every member with equal energy, and form the most divine contrast imaginable. Virgil, Æn. II. v. 199.

The Venus of Praxiteles (commonly called Venus de Medicis) belongs to this class.

136. *Roman Sculpture.* The Romans were fully sensible of the superior excellence of the Greeks in sculpture, and liberally encouraged the artists of this nation. By this means, and by collecting their best works from all parts of Greece, have been transmitted to posterity those fascinating models for imitation which have formed the taste of the Italian sculptors.

SECTION III.

MODERN SCULPTURE.

137. *Italy*. Our limits permit us not to enter into an inquiry as to the comparative merits of the different modern schools of Europe, of which Italy bears the palm. Of these it is obvious, that piety and superstition are the principal; the legends of their saints produce an incredible variety for illustrating the violent emotions of the soul in ardent devotion and the pangs of martyrdom, and it cannot be disputed that they have in many instances very nearly approached the expression and excellence of their masters.

Michael Angelo Buonarotti has been honoured by his countrymen with the title of divine, nor was *Bernini* much less deserving of this honour. In this country, Algardi and others, but principally *Canova*, have been much distinguished. Canova is undoubtedly the greatest sculptor now living, and fully equal to the second class of Grecian sculptors. A gentleman at Rome, who was often in the work-shop of Canova, on comparing a statue of *Perseus* executed by him with a cast from the *Belvidere Apollo* placed in the same room, declared that the former suffered very little by the comparison.

138. *Great Britain*. Nations, who worship images, naturally encourage those who have any taste or genius for the art of making them. If the sculptor's art does not owe its origin, it certainly owes its greatest improvements, to idolatry. The Anglo-Saxons, at the time of their settlement in this island, had the art of carving in wood, or cutting in stone, the images of their deities. When Coifi, the chief priest of the Northumbrian Saxons, was converted to Christianity, he overturned the altars, and broke down the statues of their gods, in the great temple at Godmundham, near York. The shapes of the statues of these deities, with their various emblems, are still preserved in several publications.

This rapid progress in architectural elegance was greatly assisted by a band of ingenious workmen of various countries, who, forming themselves into societies under the title of "*Free Masons*," offered their services to opulent princes, and were much attached to the bountiful Henry, and to his illustrious successor.

The ardour of our English reformers, and the party-zeal of civil wars, have left us few perfect memorials of the state of sculpture, in the early ages. Father Montfaucon says, that the art was greatly improved during the thirteenth century, and Matthew Paris mentions a monk, his contemporary, as an admirable statuary.

So great and general was the taste for painting in this period, that not only the apartments of the great, but those of private persons, were ornamented with historical pictures. When Chaucer awoke from his celebrated poetical dream, the gay objects, which his fancy had presented, had vanished, and he saw nothing,

> "Save on the wals old pourtrayture
> Of horsemen, haukes, and houndis
> And hart dire, al ful of woundis."

This, we may believe, is a real description of his own bedchamber.

It appears, upon an attentive comparison, that the figures executed between the reigns of Henry III. and Henry VII. are infinitely superior to those placed on tombs during and after the time of Henry VIII. as in his and the two preceding reigns the effigies were generally exhibited either kneeling at prayer, or cumbent, in a most miserable taste indeed, which was made still more disgusting by the custom of *painting and gilding* the drapery. In the period of the interregnum nothing was done in the art of sculpture, as, unfortunately, the æra alluded to completed the destruction begun at the Reformation, by the application of a blind principle of dislike, which prevented the preservation of the statues of saints, not as objects to excite devotion, but as the only mementos that existed that the art had ever been encouraged in England.

Some good medals were struck, during Elizabeth's reign, on great public occasions, particularly that on the defeat of the Spanish armada, of which the motto, ascribing the victory to Divine Providence, is admirable: *Afflavit Deus, et dissipantur.* "God raised a storm, and our enemies were scattered."

But it would be an ungracious task to enter upon a comparison of modern sculptors; suffice to say, that Westminster Abbey, St. Paul's cathedral, and Guildhall, present specimens of this art unrivalled by any nation. We will therefore touch upon the process of this art.

139. *Processes of the Art.* The method observed by

the modern sculptor in forming statues is as follows. A model is first formed of clay, then moulded in plaster, and lastly cast in wax. Out of a large block of marble, another is sawed of the size required; for this purpose, a smooth steel saw is used without teeth, and water and sand are cast upon the marble from time to time. It is then fashioned by taking off what is superfluous, with a steel point, and a heavy hammer of iron; and is afterwards brought nearer to the measure required with another fine point. A flat cutting instrument, with notches in the edge, is next used, and then a chisel to take off the scratches which are left. The work is made fit for polishing by rasps of different degrees of fineness.

The artist having studied his model with all possible attention, he draws upon it horizontal and perpendicular lines intersecting each other at right angles. He then copies these lines upon his marble, just as the painter makes use of transversal lines, when he copies a picture or reduces it to a smaller size. These transversal lines or squares drawn in an equal manner upon the marble and upon the model, exhibit accurate measures of the surfaces, upon which the artist is to work. The statue is *polished* by pumice-stone, smelt, and tripoli; but if a greater lustre be required, burnt straw is used.

CHAPTER V.

ENGRAVING.

SECTION I.

TO ETCH COPPER PLATES.

140. Etching is one species of engraving on copper, the lines being corroded in with aqua fortis, instead of being cut with a graver. For many purposes etching is superior to engraving; but there are others in which the subjects must be graved not etched.

In general, in engravings on copper executed in the stroke manner, etching and graving are combined, the plate is usually begun by etching, and finished with the graver. Landscapes, architecture, and machinery, receive most assistance from etching, which is not so applicable to portraits and historical designs, though in these also it has a place.

141. *The various instruments and materials used in the art.*

Copper-Plates are prepared by the coppersmiths.

Etching-points or *needles*, instruments of steel, an inch long, fixed in handles of hard wood, about six inches in length, and of the size of a goose-quill, should be well tempered, and accurately fixed in the centre of the handle. They are brought to an accurately conical point, by rubbing upon an *oil-stone*. Several of these points are necessary.

A *parallel ruler*, for drawing parallel straight lines, is best when faced with brass, as it is not then so liable to be bruised by accident.

Compasses for describing circles and measuring distances.

Aqua fortis, or what is better, spirits of nitre (nitrous acid), is used to corrode the copper. This process is called *biting* in. This liquid is kept in a bottle with a glass stopper, as its fumes destroy corks. A stopper of wax, or a cork well covered with wax, will serve as a substitute.

Bordering-wax, for surrounding the margin of the copper-plate, when the aqua fortis is pouring on, may be bought ready prepared, or made thus:

Take one third of bees-wax to two thirds of pitch; melt them in an iron ladle, and pour them, when melted, into water lukewarm; then mould it with your hand till it is thoroughly incorporated, and all the water squeezed out. Form it into rolls of convenient size.

142. *Turpentine-varnish*, used for covering the copper-plate, in any part where you do not wish the aqua fortis to bite, is diluted to a proper consistence

with turpentine, and mixed with lamp-black, that it may be seen better when laid upon the plate.

143. *Etching-ground*, used for covering all over the plate, previous to drawing with the needles, is prepared in the following manner:

Take of virgin-wax and asphaltum, each twenty ounces; of black-pitch and Burgundy-pitch, each half an ounce; melt the wax and pitch in a new earthen-ware glazed pipkin, and add to them, by degrees, the asphaltum finely powdered. Let the whole boil till such time as a drop of it upon a plate, will break when it is cold, or bending it double two or three times between the fingers. The varnish being then boiled enough, is taken from the fire, and cooled a little, and poured into warm water, that it may work the more easily with the hands, into balls for use.

Observation.—The fire must not be too violent, lest the ingredients burn; a slight simmering will be sufficient; that while the asphaltum is putting in, and after it is mixed with them, the ingredients should be stirred with a spatula; the water into which this composition is thrown, should be nearly of the same degree of warmth with the composition, to prevent a kind of cracking, which happens when the water is cold.

The varnish ought to be harder in summer than winter, it will become so if it be suffered to boil longer, or a greater proportion of the asphaltum be used. The experiment above mentioned, of the drop suffered to cool, will determine the degree of hardness or softness suitable to the season when used.

144. *To lay the ground for etching*, we proceed in the following manner. Having cleaned the copper-plate with fine whiting and a linen rag, to free it from grease, as a handle for managing it by when warm, fix a hand-vice to some part of it where no work is intended to be laid. Roll up some coarse brown paper, light one end, hold the back of the plate over the burning paper, moving it about until every part is equally heated, so as to melt the etching-ground, which should be wrapped up in a bit of taffety, to prevent any dirt, that may happen to be among it, from mixing with what is melted upon the plate. If the plate be large, heat it over a chafing-dish with clear coals. It must be heated just sufficient to melt, not to burn the ground. When a sufficient quantity

of the etching-ground has been rubbed on the plate, dab it, or beat it gently, while the plate is hot, with a small dabber made of cotton wrapped in taffety. By this operation, the ground is distributed more equally over the plate, than by any other means.

When the plate is thus uniformly and thinly covered with the varnish, it is blackened by smoking it with a wax-taper. Twist together three or four pieces of wax-taper to make a large flame, and while the plate is still warm, hold it with the varnished side downwards, and move the smoky part of the lighted taper over its surface, till it is almost black; but let not the wick touch the varnish, lest it get smeared or stained. In laying the etching-ground, take care that no particles of dust settle upon it, as that would be found troublesome in etching; the room therefore in which it is laid should be still, and free from dust.

The ground being laid, and suffered to cool, the next operation is to transfer the design to the plate.

For this purpose a tracing on oiled paper is made from the design to be etched, with pen and ink, having a very small quantity of ox's gall mixed with it, to make the oiled paper take it; also a piece of thin paper, of the same size, is rubbed over with red chalk, powdered, by means of some cotton. Then laying the red chalked paper, with its chalked side next the ground, on the plate, put the tracing over it, and fasten them both together, and to the plate, by a little bit of the bordering wax.

When all this is prepared, with a blunt etching needle go gently all over the lines in the tracing, and the chalked paper will be pressed against the ground, and the lines of the tracing transferred to it.

The plate is now prepared for drawing through the lines marked upon the ground. The etching points or needles are now employed, leaning hard or lightly, according to the degree of strength required in the lines. Points of different sizes and forms are also used, to make lines of different thickness, though this is commonly effected by the biting-in with aqua fortis.

A margin or border of wax formed all round the plate, holds the aqua fortis when it is poured on. The bordering wax already described, is put into lukewarm water to soften it, and render it easily worked by the hand. When sufficiently pliable, it is drawn into rolls, and put round the edges of the plate, in a neat wall or margin. A spout is formed in one corner, by which afterwards to pour off the aqua fortis.

The nitrous acid (spirits of nitre) is now diluted with four or five times as much water, or more (according as you wish the plate to be bit quick or slow,) and poured upon the plate. In a few minutes minute bubbles of air will fill all the lines drawn on the copper. These are removed by a feather; and the plate is every now and then *swept*, as it is called, or kept free from air bubbles. By the more or less rapid production of these bubbles, you judge of the rapidity with which the acid acts upon the copper. The biting-in of the plate is the most uncertain part of the process, nothing but experience can enable any one to tell when it is bit enough as the thickness and depth of the line cannot easily be seen till the ground is removed.

When you judge, from the time the acid has been on, and the rapidity of the biting, that those lines you wish to be the faintest are deep enough, you pour off the aqua fortis by the spout, wash the plate with water, and dry it, so as not to melt the ground.

Those lines not intended to be bit any deeper are now stopped up with turpentine varnish mixed with lamp-black, and laid on with a camel's hair pencil; when this is thoroughly dry, the aqua fortis is poured on again, to bite the other lines that are to be deeper.

This process of stopping out and biting in is to be repeated as often as lines of different degrees of thickness are to be made.

It is necessary also to be careful to stop out, with the varnish those parts from which the ground may have come off by the action of the acid, else parts will be bit that were not intended. This is called *foul-biting*.

When the biting-in is finished, remove the bordering wax and the ground, that you may see what success you have had.

To take off the bordering-wax, the plate is heated by a piece of lighted paper, which softens the wax in contact with the plate, and it comes off clean.

Oil of turpentine is now poured upon the ground, and the plate rubbed with a linen rag, to remove all the ground. Lastly, it is cleaned with whiting.

The success of the etching is now known, but it is necessary to get an impression upon paper by a copper-plate printer. This impression is called a *proof.*

If any parts are not bit so deep as were intended, the process is repeated, provided the lines are not too faintly bit. This re-biting is done as follows: melt some of the etching-ground on a spare piece of copper, dab it a little, to get some on the dabber; clean out with whiting the lines that are to be re-bit, heat the plate gently, dab it lightly with the dabber, and the parts between the lines will be covered with the ground, but the lines themselves will not be filled up, and consequently will be exposed to the action of the aqua fortis. This delicate process must be performed with great care. The rest of the plate is now varnished over, the bordering-wax put on again, and the biting repeated as at first.

Should any part be bit too deep, it is recovered or made fainter: by burnishing the part down, or rubbing it with a piece of charcoal, which will make the lines shallower, and cause them not to print so black.

Should any small parts of the lines have missed in the biting, they are cut with the graver, which is also sometimes employed to cross the lines of the etching and give it a more finished effect.

145. *Dry-pointing*, another method for softening the harsh effects usually apparent in an etching, is done by cutting with the etching-point upon the copper without any ground or varnish. This process does not make a deep line, and is used for covering the light, where delicate tints and soft shadows are wanted. By varying these processes of etching, graving, and dry-pointing, as may be necessary, the plate is worked up to the full effect intended, and then sent to the *writing engraver*, to grave whatever letters or inscriptions may be required.

SECTION II.

OF ENGRAVING.

146. *Engraving*, is the cutting of lines upon a copper-plate, by means of a steel instrument, called a graver, without the use of aqua fortis. This, the first way of producing copper-plate prints that was practised, is still used in historical subjects, portraits, and in finishing landscapes. And the necessary tools are, gravers, a scraper, a burnisher, an oil-stone, a sand-bag, an oil-rubber, and good charcoal.

The gravers are steel tempered instruments, fitted in a short wooden handle. They are of either square or lozenge: the first for cutting broad strokes, the other for fainter and more delicate lines.

The scraper, a three-edged tool for scraping off the burr raised by the graver. Burnishers are for rubbing down lines that have been cut too deep, or burnishing out scratches or holes in the copper: they are made of hard steel, well round and polished.

With the oil-stone, the gravers, etching-points, &c. are whetted.

Upon the sand-bag, or cushion, the plate is laid, for the conveniency of turning it round in any direction.

The oil-rubber and charcoal, are used for polishing the plate when necessary.

Great care is required to whet the graver nicely, particularly its belly, the two angles of the graver which are to be held next the plate must be laid flat upon the stone, and rubbed steadily, till the belly rises gradually above the plate, so that, when you lay the graver flat upon it, you may just perceive the light under the point; else it will dig into the copper, and you cannot keep a point, or execute the work with freedom. In order to this, your right arm must be kept close to your side, the fore-finger of your left hand placed upon that part of the graver which lies uppermost on the stone. To whet the face, place the flat part of the handle in the hollow of your hand, with the belly of the graver upwards, upon a moderate slope, and rub the extremity, or face, upon the stone, till it has an exceeding sharp point, which you may prove by trial upon your thumb-nail.

When the graver is too hard, as is usually the case when first bought, and may be known by the frequent breaking of the point, the method of *tempering* it is as follows: heat a poker red-hot, and hold the graver upon it, within half an inch of the point, till the steel changes to a light straw-colour; then put the point into oil, to cool; or, hold the graver close to the flame of a candle, till it be of the same colour, and cool it in the tallow; but be careful either way, not to hold it too long, else it will be too soft; in this case the point, which will then turn blue, must be tempered again. Be not hasty in tempering; for sometimes a little wetting will bring it to a good condition, when it is but a little too hard.

To hold the graver, cut off that part of the handle upon the same lines with its belly, or sharp edge, making that side flat, that it may be no obstruction.

Hold the handle in the hollow of your hand, extend your fore-finger towards the point, let it rest on the back of the graver, that you may guide it flat and parallel with the plate. Let not your fingers interpose between the plate and the graver, else they will hinder you from carrying the graver level with the plate, and from cutting the strokes clearly.

To lay the design upon the plate, after you have polished it fine and smooth, heat it till it will melt virgin-wax with which rub it thinly and equally over, let it cool. Then with a black-lead pencil, draw on paper, the design which you mean to engrave, lay it upon the plate, with its penciled side upon the wax, then press it close, and with a burnisher go over every part of the design, and when you take off the paper, you will find every line which you drew with the black-lead pencil upon the waxed plate, as if it had been drawn; then with a sharp pointed tool trace all your design through the wax upon the plate, and you may then take off the wax, and proceed to engrave.

The table, or board you work at should be firm and steady; upon the plate should rest your sand-bag; and hold the graver as above directed, proceed according to the following rules.

Rule 1. For straight strokes, hold your plate firm upon the sand-bag with your left hand, move your right hand forwards; leaning lighter where the stroke should be fine, and harder where you would have it broader. But for circular or crooked strokes, hold the graver stedfast, and move your hand or the plate, as you see convenient.

2. Learn to carry your hand with such dexterity, that you may finish your stroke as finely as you began it; if you are to make one part deeper or blacker than another, do it by degrees; and that you may do it with exactness, take care that your strokes be neither too close, nor too wide.

3. In the course of your work scrape off the roughness which arises, with your scraper; but be careful, in doing this, not to scratch the plate; and that you may see your work properly as you go on, rub it with the oil-rubber, and wipe the plate clean, which will take off the glare of the copper, and shew what you have done to the best advantage.

4. Any mistakes or scratches in the plate are rubbed out in the burnisher, and the part levelled with the scraper, polishing it again afterwards lightly with the burnisher, or charcoal.

Having thus attained the use of the graver, according to the foregoing rules, you will be able to finish the piece you had etched, by graving up the several parts to the colour required; beginning, as in the etching, with the fainter parts, and advancing gradually with the stronger, till the whole is completed.

The dry point or needle is not used till the ground is taken off the plate and is principally employed in the extremely light parts of water, sky, drapery, architecture, &c.

To prevent any obstruction from too much light, a sash, made of transparent, or fan paper, pasted on a frame, is placed sloping at a convenient distance between your work and the light, this will preserve the sight and when the sun shines cannot be dispensed with.

SECTION III.

MEZZOTINTO SCRAPING.

147. This art, of late date, is recommended by the ease with which it is executed, especially by those who understand it. In Mezzotinto prints there are no etching, or strokes of the graver, but the lights

and shades are blended together, and appear like a drawing in Indian-ink. They are therefore different from aqua tinta; but both resemble Indian-ink, and the difference is not easily pointed out. Mezzotinto is applied to portraits and historical subjects; aqua tinto to landscapes and architecture.

The tools for mezzotinto scraping are the grounding tool, burnisher, and scraper, and you proceed by the following rules.

Rule 1. To lay the mezzotinto ground, place the plate, with a piece of flannel under it, upon your table, hold the grounding tool in your hand perpendicularly; lean upon it moderately, continually rocking your hand in a right line from end to end, till you have wholly covered the place in one direction: next cross the strokes from side to side, afterwards from corner to corner, working the tool each time over the plate, in every direction, like the points of a compass; taking care not to let the tool cut (in one direction) twice in a place. This done, the plate will be full, or in other words, all over rough alike, and would, if it were printed, appear completely black.

2. Having laid the ground, take the scrapings of black chalk, and with a piece of rag rub it over the plate; or you may smoke it with candles, as before directed for etching.

3. Now take your drawing, and having rubbed the backs with red-chalk dust, mixt with flake-white, trace it on the plate.

4. To form the lights and shadows, take a blunt needle, mark the outlines only, then with a scraper scrape off the lights in every part of the plate, as clean and smooth, in proportion to the strength of the lights in your drawing, taking care not to hurt your outlines.

The burnisher is used to soften or rub down the extreme light parts after the scraper has been applied; such as the tip of the nose, forehead, linen, &c. which might otherwise, when proved, appear rather misty than clear.

Another method used by mezzotinto scrapers is, to etch the outlines of the original, as also the folds in drapery, making the breadth of the shadows by dots, which having bit to a proper depth with aqua fortis, take off the ground used in etching, and having laid the mezzotinto ground, proceed to scrape as above.

When the plate is ready for taking a proof, send it to the copper-plate printer, and get it proved. When the proof is dry, touch it with white chalk where it should be lighter, and with black chalk where it should be darker; and when the print is retouched, proceed as before, for the lights; and for the dark touches use as much as you judge necessary, a small grounding tool, to bring it to a proper colour; and when you have done as much as you think expedient, prove it again; and proceed in this manner to prove and touch till it is entirely to your mind.

SECTION IV.

OF ENGRAVING IN AQUA TINTA.

148. By *aqua tinta* engraving we can produce prints resembling drawings in Indian-ink.

The principle of the process consists in corroding the copper with aqua fortis, so that an impression from it has the appearance of a tint of ink laid on the paper. This is done by covering the copper with a powder or some substance which takes a granulated form, so as to prevent the aqua fortis from acting where the particles adhere, and by this means causes it to corrode the copper partially, and in the interstices only. When these particles have been extremely minute, the impression from the plate appears like a wash of Indian-ink; but when they are large, the granulation is more distinct, and as this may be varied at pleasure, it may be adapted successfully to a variety of purposes and subjects.

This powder, or granulation, is called *aqua tinta grain*, there are two methods of producing it.

Having etched the outline on a copper-plate, prepared in the usual way by the copper smith, procure some substance finely powdered and sifted, which will melt with heat, and when cold will adhere to the plate, and resist the action of aqua fortis. The substances used for this purpose, either separately or mixed, are *asphaltum*, *Burgundy-pitch*, *resin*, *gum-opal*, *gum-mastich*, and all the resins and gum-resins answer the same purpose. Common resin has been generally used, and answers tolerably; though gum-opal makes a better grain to resist the aquafortis.

The substance intended to be used for the grain is distributed equally over the plate; different methods of performing this part of the operation have been used by different engravers.

The usual way is to tie up the powder in a muslin bag, which strike against a piece of stick, held at some height above the plate; the powder that issues out falls gently, and settles equally over the plate; as hair powder upon the furniture after the operations of the barber. The plate being covered equally over with the dust, or powder, the operator proceeds next to fix it upon the plate, by heating it gently, so as to melt the particles. This may be done by holding under the plate lighted pieces of rolled up brown paper, moving them about till every part of the powder is melted; this will be known by its brownish change of colour. It is now to be suffered to cool, or be ready for the next part of the process.

Such parts of the drawing to be engraved as are perfectly white have their corresponding parts of the plate covered, with turpentine varnish, diluted with turpentine to a proper consistence, to work freely with the pencil, and mixed with lamp-black to give it colour; if transparent, the touches of the pencil would not be distinctly seen. The margin of the plate is also covered with varnish. When the varnish is dry, a border of wax is raised round the plate, as in etching, and you pour on the aqua fortis properly diluted with water. This is called biting-in. It is the part of the process most uncertain, and requiring the greatest degree of experience. When the aqua fortis has lain on so long that the plate, when printed, would produce the lightest tint in the drawing, it is poured off, and the plate washed with water, and dried. When dry, the lightest tints in the drawing are varnished again, and the aqua fortis poured on as before, and the same process is repeated as often as there are tints to be produced in the plate.

Although many plates are etched entirely by this method of stopping-out and biting-in alternately, yet in general, it is very difficult to stop round, and leave out all the finishing touches, as also the leaves of trees and other objects, which in this manner it is impossible to execute with freedom.

To overcome this difficulty, another process has been invented, by which these touches are laid on the plate, with as much ease and expedition as in an Indian-ink drawing. Fine washed whiting mixed with a little treacle or sugar, and diluted with water in the pencil, so as to work freely, is laid on the plate covered with the aqua tint ground, in the same manner and on the same parts as ink on the drawing. When dry, the plate is varnished with a weak thin varnish of turpentine, asphaltum, or mastich: when dry aqua fortis is poured on. The varnish immediately breaks up in the parts where the treacle mixture was laid, and exposes those places to the action of the acid, while the rest of the plate remains secure. The effect of this is, that all the places where the treacle was used, are bit-in deeper than the rest, and have all the precision and firmness of touches in Indian-ink.

After the plate is completely bitten-in, the bordering wax is taken off, by heating the plate a little with a lighted piece of paper; it is then cleared from the ground and varnish by oil of turpentine, and wiped clean with a rag and a little fine whiting, when it is ready for the printer.

The disadvantages of this method of aqua tinting are, a difficulty to produce the required degree of coarseness or fineness in the grain, and plates so engraved print not many impressions before they are worn out, and though occasionally of service it is therefore seldom used.

The second method of producing the aqua tint ground, generally practised is the following. Some resinous substance, as common resin, Burgundy-pitch, or mastich, dissolved in spirits of wine, is poured all over the plate, held in a slanting direction that the superfluous fluid may drain off, it is then laid down to dry. The spirit, in evaporating, leaves the resin in a granulated state, or rather, the latter has cracked in every direction, still adhering firmly to the copper.

A grain is thus produced with great ease, extremely regular and beautiful and in comparison of the former method much superior for most purposes. After the grain is formed, every part of the process is conducted as described above.

There are some particulars necessary to be known to secure success in the operation. The spirits of wine used for the solution must be of the best quality highly rectified. That sold in shops, generally contains camphor, which entirely spoils the grain. Rosin, Burgundy-pitch, and gum-mastich when dissolved in spirits of wine, produce grains of a different appearance and figure, and are sometimes used separately, and sometimes mixed in different proportions, according to the taste of the artist, some using some substance and some another. To produce a coarser or finer grain, it is necessary to use a greater or smaller quantity of rosin; and to ascertain the proportions the liquor may be poured on several spare pieces of copper, and the grain examined, before it is applied to the plate to be engraved. When the solution is made, it must stand still and undisturbed for a day or two, till all the impurities of the rosin have settled to the bottom, and the fluid is quite pellucid. No other method of freeing it from those impurities has been found to answer; straining it through linen or muslin, fills it with hairs, which ruin the grain. The room in which the liquid is poured on the plate must be perfectly still and free from dust, which, whenever it falls on the plate while wet, causes a white spot, which it is impossible to remove without laying the grain a-fresh. The plate must also be previously cleaned carefully with a rag and whiting, as the smallest stain or particle of grease produces a blemish in the grain. All these attentions are necessary to produce regular grain; and, after every thing that can be done by the most experienced artists, there is still much uncertainty in the process.

Artists are sometimes obliged to lay on the grains several times before they procure one sufficiently regular. The same proportions of materials do not always produce the same effect, which depends greatly on their qualities; and it is even materially altered by the weather. These difficulties are not surmounted but by experience; and those who daily practise the art, are liable to unforeseen accidents. It is to be lamented, that so elegant and useful a process should be so extremely delicate and uncertain.

As the plate is held in a slanting direction, to drain off the superfluous fluid, there will naturally be a greater body of the liquid at the bottom than the top of the plate Hence, a grain laid in this way is always coarser at the lowermost side of the plate. The most usual way is, to keep the coarsest side for the foreground, that being generally the part which has the deepest shadows. In large landscapes, various parts are sometimes laid with different grains, according to the nature of the subject.

The finer the grain is, the more the impression resembles Indian-ink, and the fitter it is for imitating drawings: but fine grains are apt to come off before the aqua fortis has lain on long enough to produce the desired depth; and as the plate is not corroded so deep, it sooner wears out in printing; coarser grains, on the contrary, are firmer, the acid goes deeper, and the plate throws off a greater number of impressions. This is evident when we consider, that, in the fine grains, the particles being small are near each other, and consequently the aqua fortis, which acts laterally as well as downwards, soon undermines the particles, and causes them to come off. If left too long on the plate, the acid would eat away the grain entirely.

The moderately coarse grains are on these accounts more sought after, and answer better than the fine grains formerly in use.

Though there are difficulties in laying properly the aqua tint grain, yet corroding the copper, or biting-in, so as to produce exactly the tint required, is even more precarious and uncertain. No rules can be laid down by which success in this process can be secured; a deal of experience and attentive observation alone enable artists to do it with certainty.

We will therefore give some hints which may be of importance to those who wish to obtain the practice of this art. The longer the acid remains in the copper, the deeper it bites, and consequently the darker the shade on the impression. It may be of some use, therefore, to have several bits of copper laid with aqua tint grounds, of the same kind to be used in the plate, and to let the aqua fortis remain for different lengths of time on each; and then to examine the tints produced in one, two, three, four minutes or longer. Observations of this kind, frequently repeated, and with acid of various degrees of strength, will assist the judgment in guessing at the tint to be produced in the plate. A magnifier is also useful to examine the grain, and observe the depth to which it is bit. No proof of the plate can be obtained till the whole process is finished. Therefore if any part appears bit too dark, it must be burnished down with a steel burnisher; but this requires delicacy and good management not to make the shade streaky; and as the beauty and durability of the grain are usually injured by it, it should be avoided as much as possible.

Those parts not dark enough, must have a fresh grain laid over them, and be stopped round with varnish, and subjected again to the aqua fortis. This re-biting requires care and attention. The plate must be well cleaned out with turpentine before laying on the grain, which should be pretty coarse, else it will not lay upon the heights only, as is necessary to produce the same grain. If the new grain is different from the former, it will be rotten, not clear and fine.

In this general account of the process of engraving in aqua tinta, we believe no material circumstance has been omitted, that can be communicated without seeing the different stages of the operation: but after all, no written directions whatever, can enable a person to practise any art perfectly, much less engraving in aqua tinta. Its success depends upon so many niceties, and attention to circumstances apparently so trifling, that the person who attempts it, must not be surprised if he does not succeed at first. It is a species of engraving simple and expeditious, if every thing goes on well; but precarious, and liable to errors which are rectified with great difficulty.

It seems adapted for imitation sketches, washed drawings, and slight subjects; but not at all calculated to produce prints from finished pictures. Nor does it appear suitable for book-plates, since it prints not a sufficient number of impressions. It cannot, therefore, be put in competition with the other modes of engraving; but, confined to subjects for which it is calculated, it is extremely useful; as it is expeditious, and may be executed with much less trouble than any other mode of engraving. But even this circumstance is a source of mischief. It occasions the production of a multitude of prints, that have no other effect than that of vitiating the public taste.

Le Prince, a French artist, invented engraving in aquatint. He kept his process a long time secret, and sold his prints at first as drawings; but he was acquainted only with the powder grain, and the common method of stopping-out. Yet the prints he produced are the finest specimens of the art. Paul Sandby first practised it in this country, and communicated it to Inkes. It is now practised throughout Europe; but no where more successfully than in Great Britain.

SECTION V.

ENGRAVING ON WOOD, GLASS, &c.

149. Engraving on wood is a process exactly the reverse to engraving on copper. In copper, the strokes to be printed are sunk or cut into the copper, and a rolling-press is used for printing it; in engravings on wood, on the contrary, all the wood is cut away, except the lines to be printed, which are left standing. A wood cut is a type, and the mode of printing is the same as that used in letter press. Box-wood, planed quite smooth, is used for this purpose. The design is then drawn upon the wood itself with a black-lead pencil; all the wood is then cut away with gravers and other tools, except the lines that are drawn. Or the design is sometimes drawn upon paper, and pasted upon the wood, which is cut as before.

This art is of considerable difficulty, there are very few who practise it, and still fewer who have attained excellence; *Bewick*, *Branstone*, *Hughes*, and some others cut most beautifully. It is, however, useful for books, not because the printing of it is cheaper, as has been supposed, than that of copper-plates; but because a block for ready reference can be put in where an engraving on copper could not. Yet it cannot be applied equally well to all the purposes to which copper-plate engraving is applicable.

150. *Etching on Glass.*

Glass resists the action of all acids, except the fluoric acid. By this, however, it is corroded as copper is by aqua fortis; and plates of glass may be engraved in the same manner as copper.

There are several methods of performing this. We shall first describe the process of etching by the fluoric acid in the *state of gas*. Having covered over the glass to be etched with a thin coat of virgin-wax (common bees-wax bleached white), draw the design upon it, in the same manner as in etching on copper. Take some *fluor spar, (Derbyshire spar)* pound it fine, put it into a leaden vessel, pour some sulphuric acid over it; place the glass with the etched side lowermost over this vessel, two or three inches above. Apply to the leaden vessel a gentle heat, which will cause the acid to act upon the fluor spar, and the gas disengaging itself will corrode the glass. When it is sufficiently corroded, the wax may be removed by oil of turpentine.

This etching may be also performed by raising a margin of bordering-wax round the glass, as on copper, and pour on the liquid fluoric acid, which acts upon the glass.

A third method of etching on glass is as follows: Having put the wax on the glass, draw your design upon it; raise a margin all round it. Then put pounded fluor spar with some sulphuric acid, diluted with water, upon the glass. The sulphuric acid will disengage the fluoric, which being absorbed by the water, will corrode the glass.

Beautiful ornaments mey thus be etched on glass, and applied to decorate windows, by painting the figure of the ornament on panes of glass with engravers' stopping varnish, and then exposing the panes to the action of the gas. The gas will corrode all the surface of the glass, except where the varnish has been put, and give it the appearance of ground glass; which may be rendered more or less opaque by lengthening or shortening the process. The parts where the varnish was applied will continue transparent and seem extremely bright. It is to be noticed, that when liquid fluoric acid is used, the lines which have been etched continue still transparent; but when the gas has been employed, the line is white and opaque, as if cut by a wheel.

151. *Engraving on Precious Stones.*

In engraving *diamonds*, the first thing is to cement two rough diamonds to the ends of two sticks, held steadily in the hand, and rub or grind them against each other, till they are brought into form. The powder serves to polish them, which is performed with a mill turning an iron wheel.

The diamond is fixed in a brass dish, and applied to the wheel, and covered with diamond dust, mixed with olive-oil, and first one face, then another is applied to the wheel. *Rubies*, *sapphires*, and *topazes*, are cut and formed on a copper wheel, and polished with tripoli diluted in water. *Agates*, *amethysts*, *emeralds*, *rubies*, and the softer stones, are cut on a leaden wheel, moistened with emery and water, and polished with tripoli, on a pewter wheel. *Lapis-lazuli*, *opal*, &c. are polished on a wooden wheel. To fashion and engrave vases of agate, crystal, &c. a lathe is used, on which are the tools, turned by a wheel; and the vessel is held to them to be engraven, either in relievo or otherwise; the tools being moistened, from time to time, with diamond-dust and oil, or emery and water.

152. *Engraving on Steel, or Dye-sinking.*

This is chiefly used in cutting seals, punches, matrices, and dies for striking coins or medals. The method of engraving with the instruments, &c. is the same for coins as for medals and counters: the only difference is in the relievo, that of coins being less than that of medals, and that of counters less than that of coins. Engravers in steel commonly begin with punches, which are in relievo, and serve for making the creux, or cavity, of the matrices and dies: though sometimes they begin with the creux, but only when the work is to be cut very shallow.

153. *Recent improvements in the arts of Engraving and Copper-plate Printing.*

Three very extraordinary improvements in the art of producing and multiplying impressions of engravings, have lately excited public attention. The first has been made by Mr. Jacob Perkins, of Philadelphia, who, from his pre-eminent skill, has for some time past been employed by the American Banks in the fabrication of notes.

It is the peculiar merit of Mr. Perkins's notes, that they are capable of exhibiting the highest perfection of the art of engraving; while at the same time every impression, though millions of them may be required, is equal to a proof.

His mode of proceeding is as follows: He first causes the subject to be engraved on a flat plate of soft steel, which, being duly hardened, is then capable of impressing a similar surface of soft steel in a cylindrical form. The cylinder in its turn being hardened, is then capable of impressing other flat plates of soft steel, or copper-plates; and one cylinder can thus multiply steel or copper plates, in any desirable number, equal in effect and delicacy to the first engraving. From these, of course, any number of impressions on paper may be taken, all fac similes of one another; and, if steel plates are used, they are all equal to proofs; or, if copper, they may be renewed as often as they begin to wear. The apparatus for transferring the impressions, as well as for producing endless lines in beautiful scrolls, and for other purposes, are highly creditable to the genius and manufactures of the United States: but Mr. P. has proved his fertility of contrivance, by inventing a machine for copper-plate printing, by which he is enabled, with 36 plates and the labour of four men, to produce 108 impressions in a minute, or 60,000 in a day. This machine consists of a wheel of four feet diameter, on the periphery of which are fixed 36 plates. By supplying an endless reef of patent paper, which is made to descend between the plates on the surface of the wheel, and a suitable apparatus for inking the plates as they pass round, in the manner of Cowper's printing press, he is enabled to take good impressions in the above surprising numbers.

The second discovery is that of a French artist, who, by employing an elastic plate, on which to take an impression, and then stretching the plate, is enabled to retake another impression from the expanded figure; from which second impression he then prints impressions of an enlarged size, corresponding line for line with the original small engraving.

The third invention is a variation of the art of Stereotyping. It is found that a certain kind of type-metal is sufficiently delicate to produce a bas-relief of a copper-plate, from which impressions can be cast and re-cast, capable of being worked at a printing-press, and of producing fair impressions on the paper of the original design. For this improvement the public are indebted to Messrs. Applegarth and Cowper; but it is practised by other persons in considerable perfection; and seems likely to be useful, in augmenting the graphic illustration of books, without increasing their cost.

CHAPTER IV.

COINING, ASSAYING, MOULDING, AND CASTING.

SECTION I.

COINING.

154. We employ gold, silver, and copper as medium of exchange; these metals having been found, by long experience, the fittest materials for money. Herodotus ascribes the invention of coins to the Lydians, Pliny attributes it to Bacchus.

In England, the standard for gold is eleven parts of pure metal, and one part of alloy. The standard for silver is eleven ounces, two dwts. of pure silver, and eighteen dwts. of alloy, making together one pound troy.

The coining of money was originally performed with a hammer, and afterwards with the mill, and then again with the hammer. By either of these methods the pieces of metal are stamped or struck with punches, or dies, on which are engraven the sovereign's effigies, arms, legend, &c. The puncheon consists of a highly tempered piece of steel, upon which the coin is sunk in relievo, and again upon the matrix, which is another piece of steel some four inches long, formed square at the bottom and rounded at its top. The moulding of the border and letters is added on the matrix with small and sharp steel puncheons, and when it is thus finished, it is called the die.

In coining with the mill, the bars or plates of gold or silver, after having been moulded and taken out of the mould, are scraped and brushed, and passed several times through the mill to flatten them, and bring them to the just thickness of the specie to be coined. But the plates of gold are heated again, and quenched in water before they pass through the mill, which renders them more ductile:—those of silver pass the mill just as they are, without any heating; and when afterwards heated, they are left to cool. The plates thus reduced as nearly as possible to their thickness, are cut into round pieces the size of the intended specie. The cutting instrument has its upper end formed into a screw; which being turned by an iron handle, lets the steel, well sharpened, in form of a punch-cutter, fall on the plates: and thus a piece is punched out. These pieces are now adjusted, and brought by filing or rasping, to the weight of the regulated standard; what remains of the plate between the circles is melted again. The pieces are adjusted in a fine balance; and those too light are separated from those which are too heavy; the first to be again melted, and the second to be filed down. The mill through which the plates pass can never be so just but there will be some inequality.

The pieces are now called blanks, and are now carried to the *blanching* or *whitening-house,* where the gold pieces have their colour given them, and the silver ones are whitened. This is done by heating them in a furnace, and when taken out and cooled, boiling them successively in two copper vessels with water, common salt, and tartar. They are then scoured well with sand, washed with common water, and dried over a wood fire in a copper sieve.

They are first marked with a *legend*, or engine, on the edges, to prevent clipping and paring. The machine used to mark the edges, is very simple and ingenious. A single man is able to mark twenty thousand coins in a day. The pieces are finally stamped, their impression being given them in a press. With all their marks and impressions, they become money; but are not current till they have been weighed and examined. The machinery invented by *Messrs. Bolton and Watt*, has long been used in the manufacture of copper money. It works the screw-presses for cutting out the circular pieces of copper, and coins both the edges and faces of the money at the same time. By this machinery four boys are capable of striking 30,000 pieces of money in an hour; and the machine acts at the same time as a register, keeping a faithful account of the number of pieces struck. This is the mode used in the new mint on Tower Hill.

155. *For Coining Medals* the process is the same in effect as that of money. The only difference worth notice is, that money having but a small relievo, receives its impression at a single stroke; but in medals, the height of relievo makes it necessary to repeat the stroke several times.

To effect this the piece is taken out from between the coins, heated, and returned again. This process, in medallions and large medals, is sometimes repeated twenty times before the full impression can be given; every time that the planchet is removed, the superfluous metal stretched beyond the circumference is taken off with a file. Medallions, and medals of high relievo, on account of the difficulty of stamping them in the press, are usually first cast or moulded in sand, like other works of that kind, and are only put into the press to perfect them.

SECTION II.

ASSAYING.

156. There are two kinds of assaying; one before metals are melted, the other after they have been struck; the first brings them to their proper fineness, and the last compares them with the standard. For the first assayers take 14 or 15 grains of gold, and half a dram of silver, if it be for money; and 18 grains of the one and a dram of the other if for other uses. The second assay is made of one of the pieces of money, which is cut into four parts. The quantity of gold for an assay is here six grains.

Assaying is also the particular mode of examining every ore and mixed metal, according to its nature with the proper fluxes, to discover not only what metals, with their proportions, are contained in ores, but also the quantity of sulphur, vitriol, alum, arsenic, and other matters.

Gold is obtained pure by dissolving it in nitro-muriatic acid, and precipitating the metal by dropping in a diluted solution of sulphate of iron; the powder which precipitates is pure gold.

Silver is obtained pure by dissolving it in nitric acid, and precipitating it with a diluted solution of sulphate of iron. With metallurgists the mass consists of 24 imaginary parts, called *carats.* Gold of 24 carats means *pure* gold; the number of carats mentioned specifies the parts of pure gold, and what that number *wants* of 24 carats, indicates the quantity of base metal in the alloy. Gold of 12 carats, means 12 parts of gold, and 12 of another metal. Gold coins of Great Britain are of 22 carats *fine,* they contain, therefore, 11 parts of gold and one of copper.

Parting is the separation of gold from silver when both are contained in an alloy; it is founded on the *insolubility* of gold, and the solubility of silver in nitric acid.

SECTION III.

OF MOULDING.

157. The art of taking impressions from pieces of sculpture, medals, &c. is of importance in the fine arts, and we now treat of it.

To procure a cast from any figure, bust, medal, &c. it is necessary to obtain a mould, by pressing upon the thing to be copied some substance capable of being forced into all the cavities or hollows of the sculpture. When this mould is dry and hard, some substance which will fill all the cavities of the mould is poured into it, the form of the original from which the mould was taken, is now accurately represented.

Moulding in any particular manner depends upon the form of the subject. When there are no projecting parts but such as form rectilineal angles with the principal surface of the body, nothing more is necessary than to cover it over with the substance of which the mould is to be formed, and to take it off clean, and without bending.

The substances used for moulding are various, according to the nature and the situation of the sculpture. If it may be laid horizontally, and will bear to be oiled without injury, plaster of Paris may be employed. This is prepared in a fine powder mixed with water, and poured over the mould to a convenient thickness, after oiling it, to prevent the plaster from sticking.

A composition of bees-wax, resin, and pitch, makes a very desirable mould, if many casts are to be taken. If the situation of the sculpture be perpendicular, clay, or some similar substance, must be used. The best kind of clay is that with which sculptors make their models; it is worked to a due consistence, and having spread it out to a size sufficient to cover all the surface, it is sprinkled over with whiting, to prevent it from adhering to the original. Bees-wax and dough, or the crumb of new bread, may also be used for moulding some small subjects, as impressions of seals and bijoux.

When there are undercuttings in the bas-relief, they must be first filled up before it can be moulded; otherwise the mould could not be got off. When the casts are taken afterwards, these places must be worked out with a proper tool.

When the model, or original subject, is of a round form, or projects so much that it cannot be moulded in this manner, the mould must be divided into several parts; and it is frequently necessary to cast several parts separately, and afterwards to join them together.

In this case, the plaster must be tempered with water to such a consistence, that it may be worked like soft paste, and laid on with some convenient instrument, compressing it till it adapt itself to all parts of the surface. When the model is thus covered to a convenient thickness, the whole is left at rest till the plaster become firm, so as to bear dividing without falling to pieces, by any slight violence: it must then be divided into pieces to be taken from the model. This is done by cutting it with a thin bladed knife; being now divided, it must be cautiously taken off, and kept till dry: but, before the separation of the parts is made, they are notched across the joints, at proper distances, that they may with certainty be put together again. The art of properly dividing the moulds, to make them separate from the model, requires dexterity and skill. Where the subject is of a round or spheroidal form, it is best to divide the mould into three parts, which will then easily come off from the model; and the same will hold good of a cylinder, or any regular curve figure.

The mould being thus formed, and dry, and the parts put together, it must be first oiled, and placed in such a position that the hollow may lie upwards. It is then filled with plaster mixed with water; and when the cast is perfectly set and dry, it is taken out of the mould, and repaired when necessary. This finishes the operation.

In larger masses, where there would otherwise be a great thickness of the plaster, a core may be put within the mould, as was observed in regard to the casting of statues, to produce a hollow in the cast. This saves expense of plaster, and renders the cast lighter.

In the same manner, figures, busts, &c., may be cast of lead, or any other metal in the moulds of plaster or clay; the moulds must be perfectly dry, for should there be any moisture, the sudden heat of the metal will convert it into vapour; and produce by its expansion, an explosion, that would blow the melted metal about to the great danger of the artist.

SECTION IV.

CASTING.

158. *To take a Cast in Metal from any small Animal, Insect, or Vegetable.*

PREPARE a box, sufficiently large to hold the animal, in which it must be suspended by a string, the legs, wings, &c. of the animal, or the tendrils, leaves, &c. of the vegetable, must be separated and adjusted in their right position by a pair of pincers. A due quantity of plaster of Paris mixed with talc, must be tempered to a proper consistence with water, and the sides of the box oiled. Also a straight piece of stick must be put to the principal part of the body, and pieces of wire to the extremities of the other parts, that they may form, when drawn out after the matter of the mould is set and firm, proper channels for pouring in the metal, and vents for the air, which otherwise, by the rarefaction it would undergo from the heat of the metals, would blow it out, or burst the mould.

In a short time the plaster will set, and become hard; the stick and wires may now be drawn out and the frame in which the mould was cast taken away; and the mould must then be put, first, into a moderate heat, and, afterwards, when it is as dry as can be rendered by that degree, removed into a greater, which may be gradually increased, till the whole be red hot. The animal or vegetable inclosed in the mould will then be burnt to a coal; and may be totally calcined to ashes, by blowing for some time into the charcoal and passages made for pouring in the metal, and giving vent to the air. This operation at the same time that it destroys the remainder of the animal or vegetable matter, will blow out the ashes. The mould is then allowed to cool gently, the destruction of the substance that had been included in it, has now produced a corresponding hollow; but it may nevertheless be proper to shake the mould, and blow with bellows into each of the air vents to free it wholly from any remaining ashes; where there may be an opportunity of filling the hollow with quicksilver, it will be found an effectual method of cleaning the cavity, as all dust and ashes, will necessarily rise to the surface of the quicksilver, and be poured out with it. The mould being thus prepared, must be heated very hot, when used, if the cast is to be made of copper or brass, but a less degree will serve for lead or tins. The metal being poured into the mould, it must be gently struck, and then suffered to rest till it be cold; it is then carefully taken from the cast, but without force; such parts of the matter as appear to adhere more strongly, are to be softened, by soaking in water till they be entirely loosened, that none of the more delicate parts of the cast may be broken off or bent.

When talc cannot be obtained, plaster alone may be used; it is apt however to be calcined, by the heat used in turning the animal or vegetable from whence the cast is taken, and to become of too incoherent and fusible a texture. Stourbridge clay, washed perfectly fine, and mixed with an equal part of fine sand, may be employed. Pounded pumice-stone, and plaster of Paris, in equal quantities, mixed with washed clay in the same proportion, make excellent moulds.

159. *To take a Cast in Plaster from a Person's Face.*

The person whose likeness is required in plaster, lays down on his back, the air is tied back, so that none of it may cover the face. Into each nostril a conical piece of stiff paper open at both ends is conveyed to allow of breathing. The face is then lightly oiled over with salad-oil, to prevent the plaster from sticking to the skin. Fresh burnt plaster is mixed with water to a proper consistence, for pouring it in spoonfulls all over the face (taking care the eyes are shut,) till it is entirely covered to the thickness of a quarter of an inch. This substance will grow sensibly hot, but this the patient must not fear; for in a few minutes the plaster will be hard.

This being taken off, will form a mould, in which a head of clay may be moulded, and therein the eyes may be opened, and such other additions and corrections may be made as are necessary. Then, this second face being anointed in oil, a second mould of plaster is made upon it, consisting of two parts joined length-wise along the ridge of the nose; and in this a cast in plaster is taken, as an exact likeness of the original.

160. *To take Casts from Medals.*

To take copies of medals, a mould must first be made; of plaster of Paris, or of melted sulphur.

After having oiled the surface of the medal with a little cotton, or a camel's hair pencil dipped in oil of olives, a hoop of paper must be put round the medal, standing up above the surface of the thickness you wish the mould to be. Take now some plaster of Paris, mix it with water to the consistence of cream, and with a brush rub it over the surface of the medal, to prevent air-holes from appearing; then immediately afterwards make it to a sufficient thickness, by pouring on more plaster. Let it stand half an hour, when it will have grown so hard, that you may safely take it off; then pare it smooth on the back and round the edges neatly. In cold or damp weather it should be dried before a brisk fire. When the mould is large if you cover its face with fine plaster, a coarser sort will do for the back: but no more plaster should be mixed up at one time than can be used, as it will soon get hard, and cannot be softened without being burned over again.

Note. Sulphur must not be poured upon silver medals, as this will tarnish them.

To prepare your mould for casting sulphur or plaster of Paris into it, take half a pint of boiled linseed-oil, and one ounce of oil of turpentine, and mix them together in a bottle; dip the surface of the mould into this mixture; take the mould out again, and when it has sucked in the oil, dip it again. Repeat this till the oil begins to stagnate upon it; then take a little cotton wool, hard rolled up, to prevent the oil from sticking to it, and wipe it carefully off. Lay it in a dry place for a day or two (if longer the better,) and the mould will acquire a very hard surface from the effect of the oil.

To cast plaster of Paris in this mould, proceed with it in the same manner as above directed for obtaining the mould itself, first oiling the mould with olive oil. When casts are wanted of sulphur the material must be melted in an iron ladle.

161. *To take Casts with Isinglass.*

Dissolve isinglass in water over the fire. With a hair brush lay the wetted isinglass over the medal. Cover it properly and let it dry. When hard, raise the isinglass with the point of a knife, and it will fly off like horn, leaving a sharp impression of the medal.

You may make the isinglass of any colour, by mixing that colour with it when in a state of solution: or you may breathe on the concave side, and lay gold leaf on it, which by shining through will make it appear like a gold medal. A little carmine mixed with the isinglass will give it the appearance of a copper medal, observing to lay the gold on the concave side.

162. *To cast small works in sand.*

The sand is usually a soft yellowish clammy substance: but as we see it in an iron foundery, it is black from the charcoal which the workmen strew over it.

This sand, after being placed over a trough to receive it, is worked on a board, with a roller, and a knife. The workmen then take a board, putting a ledge round, fill it with sand, a little moistened, to make it cohere. Then the wood, or melted models of what is intended to be cast, are applied to the mould, and pressed the sand, to leave the impression. Along the middle of the mould, half of a small brass cylinder is laid, the metal runs this chasm, into the models, from this are placed several others, to each model placed in the frame.

After the frame is finished, the workmen then take out the patterns, by loosening them all round, that the sand may not give way. They then work the other half of the mould with the same patterns, in another frame. In this last frame are pins, which, entering into correspondent holes in the other, make the two cavities of the pattern fall exactly on each other. The frame thus moulded, is carried to the melter. He extends the chief canal of the counterpart, adds the cross canals to the several models in both, and strewing mill-dust over them, dries them in an oven. Both parts of the mould being dry, are joined by the pins, and screwed up like a press. While the moulds are preparing, the metal is fusing in a crucible of a size proportionate to the quantity of metal intended to be cast.

163. *Bell-foundery.*

In casting bells, the composition used, is termed bell-metal, and is made of copper, with one-sixth of tin, the usual proportion for church bells; in clock-bells, the proportion of tin is smaller, and a little zinc is added, especially for very small bells.

The dimensions of the core, and the wax of bells, especially if it be a ring of several bells that is to be cast, are not left to chance, or the caprice of the workman, but must be measured by scale, which gives the height, aperture, and thickness necessary for the several tones required. The several mouldings, and other ornaments and inscriptions to be represented.

in relievo on the outside of the bell, are formed on the wax. The clapper, or tongue, is not a part of the bell, but is furnished from other hands. In Europe, the clapper is usually of iron, and is suspended in the middle of the bell. In China, it is only a huge wooden mallet, struck by force of arm against the bells; whence there can be but little of that harmony so much admired in our bells.

164. *To cast Cannon.*

The casting *cannons, mortars,* and other pieces of ordnance, is like that of statues and bells; especially as it regards the mould, wax, shell, furnaces, &c.

The metal is different, however, having a mixture of tin, which is not in that of statues; and only half the quantity of tin that is in bells, at the rate of ten pounds weight of tin to a hundred of copper. Cannons are always thickest at the breach, where the greatest effort of the gunpowder is made, and diminishing thence to the muzzle; so that if the mouth be two inches thick of metal, the breech is six. Its length is measured in calibres, or diameters of the muzzle. Six inches at the muzzle require twenty calibres, of ten feet in length; there is about one sixth of an inch allowed for the deviation of the ball, and in this manner are all our guns estimated.

Casting has been, though very rarely, attended with the most afflicting and awful events. During a tremendous thunder-storm, the workmen, in presence of all the resident proprietors, were casting a tilt-shaft, about five tons weight, in a perpendicular mould: when the casting was nearly complete, the liquid mass suddenly shot up, like a cataract of fire from the orifice of a volcano, and, mingled with clouds of heated sand, fell in red-hot flakes on every side. Of about forty persons present twenty-two were burnt more or less severely; but particulars of the manner in which wounds and death were inflicted during this dreadful explosion, would be too shocking for perusal. Three men perished on the spot, six others died afterwards; the lives of the remainder, many of whom were grievously scorched and lacerated, were preserved. Yet this is the only fatal accident which has occurred from burning, at Thorncliffe iron-works, since their establishment, twenty-five years ago, though castings double the weight of this have been executed there. The immediate cause of this unparalleled catastrophe seems beyond ascertainment. From any failure of the cast-iron moulds it could not be—they were found perfect after the accident: from moisture within the pit seems nearly as impossible, the casting having been comparatively completed before the eruption. It is the opinion of the proprietors that some communication took plaee between the electric fluid, with which the atmosphere was highly charged at the time, and the dense sulphurous vapour arising from the upright column of molten mineral in its matrix, whereby an explosion, resembling an earthquake in violence and noise, was occasioned. The building, which is nearly new, and exceedingly substantial, was not injured by the shock: had it been otherwise, all present must have been slain and burned at once in the flames and the ruins. All that can be known, however, amounts but to this—that, like Jacob awaking from his dream, both the dying and the surviving might have exclaimed, "How dreadful is this place! Surely the Lord was in this place, and we knew it not."

165. *To make Gunpowder.*

Though irrelevant to the subject of this chapter, we here mention the composition of gunpowder.

Gunpowder is made in this country of seventy-five parts of nitre, fifteen of charcoal, and ten of sulphur, mixed together, and granulated. When the materials have been reduced to fine dust, they are mixed and moistened with water, vinegar, wine, or spirits of wine, &c. They are then beaten for twenty-four hours, generally by mills, and afterwards pressed into a hard solid cake.

The *corning*, or *graining*, is performed by breaking the dry cake into small pieces, and running it through a sieve; which makes the grains of any size. The *glazing* is thus effected:—a hollow cylinder or cask mounted on an axis, and turned by a wheel, is half filled with powder, and turned for six hours, and by the mutual friction of the grains of powder, it is smoothed or glazed. The explosive effect of gunpowder is wonderful. The velocity of expansion of the *flame*, when fixed alone in a piece of artillery, is above 7000 feet in a second, and four times as much at the moment of explosion.

166. *Letter-foundery.*

The two things principally to be regarded in the casting of letters, are the *matter* and the *matrices*. The *matter* is a compound metal; partly copper, and partly lead, mixed in a certain proportion, which every letter-founder regulates at his own discretion, to this he adds a quantity of other metal, to render the composition harder.

The *matrices* of the letters are pieces of copper, on which the impression of the intended character has been cut, or struck by puncheons, &c. graven in relievo. Each letter has its proper matrix:—there are particular ones for points, figures, rules, head-pieces, and other ornaments of printing: the quadrats, being only of lead, and not intended to leave any impression, are cast in moulds without matrices: each matrice has its puncheon of steel, well tempered. The matrices being struck, are put each at the end of an iron mould inclosed between two thin pieces of board, three inches square; the two upper angles being cut off, so as to compose an irregular hexagon. Every thing belonging to the mould being disposed, the workmen begin to prepare the matter.

The furnace, whereon the bason is placed for the metal to be melted in, is made of the same materials as crucibles. Over the furnice is placed the melting bason, or copper; divided into two equal parts, by a perpendicular partition, to melt either hard or soft metal. In this bason they melt only the matter already prepared; that is, the mixture or composition made in the crucibles. A small iron ladle serves to skim off the impurities from the melted metal which are melted over again. Two workmen are employed at each furnace; they have a table on which they lay the characters as soon as they are cast, to run the metal into the mould, the founder holds in his ladle just enough for one letter. Having filled this ladle, he pours the metal through a funnel, into the matrix or character. He then opens the mould and takes out the character; and without loss of time shuts it again, replaces the matrix, and casts a new letter. It is incredible with what expedition all this is done. The letter being cast, the workmen views it before he breaks off the jet, to see whether it be perfect, otherwise he throws it among the refuse of the fount.

When the letters are composed, they remain to be *justified*, to height and thickness. In order to do this, the workmen use a little copper-place, as a level. The justification, as to thickness, is made on a piece of marble; and that for the height on an iron compository. The justification of the height is guided by the *m* of some body of characters already justified. All that remains is to make that groove which every letter has at bottom, precisely opposite to the eye, or upper part, or face of the letter. To effect this, they invert a long line of letters, they set between two cheeks of wood, which pressing very tight, enable the workman to run his plane along the line of the letters so inverted, and thus to form the groove. The letters are now fit for the printer's use.

167. *To cast Statues.*

To cast a bronze statue, the figure must have a mould made with a mixture of one part of plaster of Paris, and two of brick dust. In the joints, channels must be cut, tending upwards, to give vent to the air.

When the mould is made, a layer of clay is spread over the inside as thick as the intended bronze: then the mould is closed, and the hollow within the layer filled up with two-thirds of brick-dust, and one of plaster mixed with water. This is the core. If it be a large figure, bars of iron are laid in the mould to support it; the mould is now opened, and the clay taken out. The core is then laid in the mould and supported by short bars of bronze, after which the liquid metal is conducted in by a sloping channel from the furnace.

CHAPTER VI.

DOMESTIC ARTS.

SECTION I.

THE MAKING OF BREAD.

168. BREAD is the staff of life. All people use it in one way or another, even though composed of materials very dissimilar. We use wheaten bread:

some use bread made of oats, others convert dried fish into meal for bread; and nature furnished the bread fruit tree to natives of the South-Sea Islands.

The bread fruit tree grows abundantly on the Ladrone Islands. In the Society Islands it is as large as a moderate sized oak; its leaves are about a foot and a half long, of an oval shape, like those of the fig-tree, which they resemble in colour: and, when broken, exude a milky juice. The fruit is shaped like a heart, and grows to the size of a child's head. Its rind is thick, green, and covered with excrescences. The internal part of the rind is a pulpy substance, full of twisted fibres; this pulp is softer towards the middle, where a small cavity is formed, containing no kernels or seeds. It affords much nourishment, and is very satisfying. Its taste is harsh, and similar to potatoe-bread.

The Cassiva bread of the Americans is made from a species of starch prepared from the roots of a plant. They are peeled and pressed, the juice which exudes is a deadly poison, used by the Indians to poison their arrows. The white starch, however, which is deposited, when properly washed, is perfectly innocent and makes bread!

169. The materials of which loaf-bread is principally made, are the seeds of farinaceous vegetables, as wheat, rye, and barley. Potatoes, oats, beans, peas, rice, maize, millet, buck-wheat, &c. contain no gluten, and cannot be made into bread without a certain quantity of flour. The component parts of wheaten, barley, and rye flour, are starch, gluten, and saccharine mucilage.

1. Fecula, or starch of wheaten flour, forms the most nutritive part of grain. It is found in all seeds, and is very abundant in the potatoe, as almost all the root consists of starch. 2. Gluten, is the principal substance contained in wheaten flour. It is necessary for the production of good light bread: the quality of the bread being exactly in proportion to the quantity of the gluten contained in the flour: wheat flour alone contains it in any considerable quantity.

Flour could not be made into bread without gluten, for the dough rises in consequence of this substance. To obtain gluten, you put a handful of flour into a cloth, pass it through water, and press it with the hand; the starch or fecula passes off, and this elastic substance remains. Gluten forms one-fifth part of bread-corn, ferments readily, and is soluble in acids, but not in water. 3. Saccharine mucilage is soluble in cold water, and separable from it by evaporation. The saccharine part may be converted into an ardent spirit, but the mucilage in bread that has been kept some time, tends to acidity, and becomes mouldy. There are three general methods of making bread, and these we will now illustrate:—

1. Unleavened bread is made of flour mixed with water. The sea and other biscuits, the Jews' pass-over cake, the oaten and barley bread of Scotland, are of this nature.

2. Leavened bread mentioned in the Jewish history, has been known to mankind from the earliest age of society. It is thus made. A portion of dough is left till it ferments, or becomes sour. This is mixed with other dough, and causes it to rise; carbonic acid gas is thrown out, a vinous smell is perceived; and an active fermentation goes on.

3. Bread made with yeast, or family bread, is thus made. To half a bushel of wheaten flour add six or eight ounces of salt, a pint of yeast, and six quarts of water. Mix the whole together and cover it up with a blanket; this operation is called setting the sponge:—flour must then be added, and the mass kneaded till it attain a proper consistency. It must then stand for four or five hours, till it rises properly, and afterwards you put it into the oven.

Obs. A sack of flour contains about 280lbs. and will make 80 quartern loaves, allowing three and a half pounds of flour for each. Before the loaf goes into the oven it weighs 4lbs. 15oz. but loses nine or ten ounces in baking.

In each loaf bakers usually put two ounces of alum, though this is prohibited by law. The alum binds the bread, and makes it more compact, but then it is less wholesome: and it also whitens old flour. Besides the bread just described, there are wheaten and household bread. The former is made of flour, with a mixture of the finer bran; the latter of the whole substance of the grain, without either taking out the coarse bran or the fine flour.

French bread is made by adding ten eggs, and a pound and a half of fresh butter, and as much yeast to half a bushel of fine flour. The whole mass is tempered with new milk, warmed pretty hot; after being allowed half an hour to rise, it is made into loaves, or rolls, and is washed over with an egg beaten with milk; the oven is of a gentle heat.

Obs. Bread is highly nutritious. And since, among the animal fluids the saliva is essentially necessary, dry food should be used as a stimulus to draw it forth; thence we eat bread with meat. Bread blends the oil and water of food in the stomach, which it stimulates; and it is peculiarly proper for that purpose, being bulky without too much solidity, and firm without difficulty of solution.

SECTION II.

BREWING, &c.

169. Brewing is a very ancient domestic art. Before the malt is used it must be bruised, between rollers; and soft water is used for mashing and fermentation. The first step in brewing is mashing. This is done in a tub furnished with a false bottom, pierced with holes, and moveable or fixed a few inches above the real bottom. There are two side-openings between the two; to one is fixed a pipe to convey water into the tun, and the other is used for drawing the liquor out. The malt is to be strewed over the false bottom, and a proper quantity of water let in from the upper copper; after which the mass is beaten by poles, or a machine like a rake or harrow, and moveable on a perpendicular beam with transverse arms for the rakes. When the mashing is completed, the tun is covered to prevent the escape of the heat, and the whole is suffered to stand, that the insoluble parts may separate from the

liquor: the side-hole is then opened, and the clear wort discharged into the lower copper. The most eligible temperature in mashing is from 185 to 190 degrees, but for the first mashing the heat of the water must be less, and so in proportion to the dark colour of the malt.

The wort of the first mashing is always the richest in saccharine matter, but to exhaust the malt, a second and third mashing are requisite *. Thirty gallons may be drawn from each bushel of malt, for sound small beer; six and a half gallons only for strong ale. Every bushel of malt absorbs, or retains, about three and a half gallons of water.

The next process is boiling and hopping; if only one kind of liquor is to be made, the produce of the three mashings should be mixed; if both ale and table beer are required, the wort of the first, or first and second mashings, is for the ale, and the remainder for the beer. The wort intended for the same liquor, after it comes from the tun, is put into the lower copper, and mixed with a proportion of hops; and the better the wort the greater the quantity of hops will be wanted.

Hops contain gallic acid and tanning matter, and deprive the sweet wort of the mucilage which occasions the beer to keep without turning sour.

When the hops have been mixed with the wort in the copper, the liquor is made to boil as fast as possible. When it is discharged into shallow tubs, called coolers, where it remains till it is cool enough to undergo fermentation.

From the coolers the liquor is transferred to the working tun, and with it is mixed a gallon of yeast to four barrels of beer. In four or five hours the fermentation commences, but it requires from 18 to 48 hours before the wort is fit to be barrelled. The fermentation still goes on in the barrels, and in a few days a copious discharge of yeast takes place from the bung hole, and the greater portion of gluten is disengaged. In brewing, the gluten is not wanted, but in bread is indispensable, and alone renders it fit for use.

Care must be taken to fill up the barrel every day with fresh liquor; this discharge lessens daily, and ends entirely

* Brewers use a sacchrometer to ascertain the goodness of the wort. This instrument is a kind of hydrometer, and shows the specific gravity of the wort, rather than the exact quantity of saccharine matter contained in it.

in about a week, when the bung-hole is closed, and the liquor is fit for use, after standing from a fortnight to three months, according to its strength and the temperature at which it has been fermented. The fining of the beer is done by the use of isinglass. But drugs are sometimes used to give a narcotic and stupefying power to the beer.

Ale, a fermented liquor extracted from malt, has a less proportion of hops than beer. It was first made in Egypt as a substitute for wine, and was a favourite drink with the Anglo-Saxons and Danes. Pale ale is accounted more wholesome than brown ale, because it is brewed from malt slightly roasted, while the latter is made of drier malt.

To make malt, barley is steeped in cold water
170 about 40 hours. When it is sufficiently steeped, the water is drained off, and the barley spread upon the malt floor, where it is formed into a rectangular heap, about 16 inches deep. In this state it remains about 26 hours. It is then turned with wooden shovels, and diminished in depth: this is repeated twice or thrice a day, and the grain is constantly spread, till its depth does not exceed a few inches. On the couch it absorbs oxygen from the atmosphere, which it converts into carbonic acid; the temparature gradually increases, and in four days the grain, now 10 degrees hotter than the atmosphere, becomes moist, and exhales an agreeable odour: this is termed the sweating.

The malster must keep the temperature from becoming excessive by turning. At the period of sweating, the roots of the grains appear. In one day after the sprouting of the roots, the rudiments of the future stem, called acrospire, may be seen to lengthen. As it shoots along the grain, the mealy part undergoes a considerable change. The glutinous and mucilaginous matter is taken up and removed, the colour becomes white, and the texture so loose that it crumbles to powder between the fingers. When the acrospire has come nearly to the end of the seed, the prooess is stopped by drying the malt upon a kiln. It is then cleaned. When the grain is dried gradually, or in the sun, it is called air-dried malt; or when quickly, by the heat of a stove, kiln-dried;

the latter being charred partially, is brown, more or less intense, and contains less fermentable matter than the air-dried, or pale malt. Burnt sugar is frequently used to colour beer.

170. *To make Cyder and Perry.*

171. To make Cyder, a brisk pleasant liquor, take the apples which drop from time to time from the trees, and collect them in an open part of the orchard; disregarding the weather. When the apples have lain a sufficient time; a month or six weeks; they are then ground in a mill, and the ground fruit is received into a large vessel. The next operation is pressing; the next, the *stumming* of the cider, which is performed by burning a match in a clean hogshead moist from rincing, and racking the cyder on the fret into it.

Obs. *Stum* is the rich *must* of good cyder, blended with the vapour of the burning match, which prevents fermentation. Hereford and Devonshire are celebrated for their cyder.

Perry is a liquor made from pears exactly as cyder is made from apples. The pears must be ripe. Worcestershire and Gloucestershire are famed for their perry.

SECTION III.

DISTILLATION, &c.

172. Distillation is the art of separating or drawing off, by the aid of fire, the spirituous, watery, oily, or saline particles of a mashed body from the grosser and more earthy parts, and afterwards condensing them by the application of cold.

The fire is either applied immediately to the vessels in which the substances are to be distilled, or mediately, by means of water, sand, or iron-filings. The present method of distilling is by *ascent*, or raising the spirit above the fire. Of this there are two methods. 1. *Right;* this process is managed with a common alembic, in which the liquor is raised, and then descends or drops into a receiver; and is chiefly used when the nature and consistence of the mash are such, as to admit of a direct ascent; as in vegetables.

2. *Oblique* distillation is performed laterally and in crooked vessels, termed *retorts*. It is employed in distilling those more solid bodies, whose particles are too heavy to be raised to the top of a common still, or alembic;—of this description are salts and fossils. The process of distilling compound spirits, such as clove, lemon, or citron-water, is the same as that adopted in distilling brandy, and other spirits.

173. *Brandy distilled from Potatoe Berries.*

For some years, large quantities of brandy have been distilled in France from potatoe-berries. The process is very simple:—the berries are gathered at full maturity; they are then carefully bruised, by means of the cylinders made use of by distillers to grind boiled potatoes. The pulp is then put into vats, and left to its natural fermentation: when this is over, it is distilled, and there is obtained, generally, in brandy nineteen degrees strong, (near Dutch proof,) a hectolitre (a hundred quarts) for every twenty or twenty-four hectolitres of uncrushed berries. This spirit is pretty well tasted.

It is to be observed, that these berries produce, on fermentation, as much brandy as the grapes of Lorraine; in fact, these latter yield little less than half their volume in wine, which, one year with another, would only yield about one-tenth of brandy. There is, however, notwithstanding, an essential chemical difference in the composition of these two fruits.

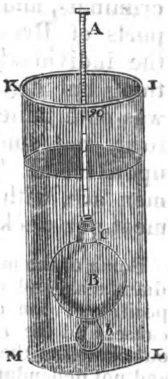
174. *Preparation of Aromatic Vinegar.*

From the peculiar property which acetic acid has of dissolving camphor and the essential oils, it has been used to make the substance known by the name of Aromatic Vinegar, which is used for smelling in all cases of fainting, lowness of spirits and nausea.

Pour one ounce of acetic acid into a phial containing half a drachm of camphor and half a drachm of oil of Bergamot, or any other oil, according to the taste of the person who uses it. Cork the phial and shake it frequently: the camphor and oils will soon be dissolved, and the whole will then be fit for use. The Aromatic Vinegar is generally used by dipping a sponge in it, and enclosing it in a silver box, which has a gilt plate perforated with holes, for the odour of the compound to ascend.

175. *The Hydrometer.*

The hydrometer AB is used for determining the specific gravity of various liquids, and of sea water in different latitudes. It consists of a ball B having a small stem AC projecting from it, terminated by a cup, and on the opposite part of the ball is a weight *b* sufficient to cause it to sink when immersed in distilled water of the temperatnre of 50° until a mark made on the stem is on the surface of the water. The weight of the hydrometer scarcely exceeds 1000 grains, consequently the weight of distilled water displaced by it will also be a 1000 grains. There accompanies this instrument a box containing circular weights of 10, 20, 30, &c. grains, and in separate papers are weights of single grains and tenths. The tenths are made of wire, and their value may be known by the number of parts into which they are bent. The marine hydrometer is fitted into a mahogany box inclosed in a tin case, and intended to contain the sea water.



To use the instrument, fill the tin vessel IKML nearly with the sea water, and place the hydrometer in it. Carefully examine whether any bubbles of air are attached to the hydrometer, and if so, remove them with a hair pencil or feather. Place now weights on the cup sufficient to sink the hydrometer to the mark on the stem. In doing this, it will be necessary to force the ball of the hydrometer below the surface of the water by pressing on the cup. When the hydrometer is steady, observe whether the surface of the water round the stem is depressed or elevated; if the former, the weight is too great, if the latter, too small. Nothing more is necessary than to register the number of weights thus placed in the cup of the hydrometer, which added to 1000 will give the specific gravity required, and immediately afterwards to ascertain the temperature of the water by placing a thermometer in it. For this the thermometer attached to the portable barometer will be found convenient. The hydrometer should be carefully wiped previous to returning it into its case.

176. *Distilled Sea Water used for Cooking, &c. and as a Beverage.*

Some very extensive experiments have been made in France on the use of distilled sea-water in the preparation of food, and as a beverage, and they have afforded favourable results. The men upon whom the experiments were made, were principally criminals, and for the most part galley slaves at the ports of Brest, Toulon, Rochefort, &c. Most of the individuals knew that they were drinking nothing but distilled sea-water, and that a suspicion was entertained of some particular effect belonging to it, but some were not aware of the trials made upon them. They were dieted in the way that seamen are, with the exception of two meals of fresh meat per week.

Some of the men complained of pains in the bowels and diarrhoeas, and others suffered under various slight indispositions; the complaints however appeared to be without cause, and the real indispositions, from their removal without changing their mode of living, were shewn to be casual and not dependant upon the water. The health of many of them appeared to be improved during the time they remained subjects of trial.

The individual experience of intelligent persons has also confirmed the favourable conclusion drawn from the above experiments, and in no case has it been found to possess the sharp taste or caustic qualities ascribed to it.

The inference drawn by the Commissioners who were appointed to ascertain the effects arising from the constant use of distilled sea-water is the same; they all conclude that it may be employed both in cooking, and as a beverage, and that it affords a resource which at times may be of great importance; as in long voyages, and particularly in those of discovery.

177. *Pyroligneous Acid.*

M. Monge discovered that the acid obtained by the distillation of wood has the property of preventing the decomposition and putrefaction of animal substances. It is sufficient to plunge meat for a few moments into this acid, even slightly empyreumatic, to preserve it. Cutlets, kidneys, liver, rabbits, &c. which were thus prepared as far back as the month of July, 1819, are now October, 1820, as fresh as if they had been just procured from market. Carcases washed with Pyroligneous Acid, have not for three weeks exhibited any sign of decomposition. Putrefaction not only stops, but even retrogrades by its use.

We now know why meat merely dried in a stove does not keep, while that which is smoked becomes unalterable. We have here an explanation of the theory of hams, of the beef of Hamburgh, of smoked tongues, sausages, red herrings, of wood, smoked to preserve it from worms, &c. &c.

Dr. Jorg, professor of Leipsic, has made many successful experiments of the same nature. He has entirely recovered several anatomical preparations from incipient corruption, by pouring this acid over them. With the oil which is produced from wood by distillation in the dry manner, he has moistened pieces of flesh already advanced in decay; and, notwithstanding the heat of the weather, soon made them as dry and firm as flesh can be rendered, by being smoked in the smoking-room. All traces of corruption vanish at once when the vinegar of wood, or the oil of wood, is applied to the meat with a brush. The professor has also began to prepare mummies of animals, and has no doubt of success. He promises great advantages to anatomy, domestic economy, and even to medicine, from this discovery; for the remedy seems very fit to be applied internally and externally in many disorders.

It is made in the large way at an establishment at Battersea, of one uniform strength of 50 degrees, by the new Excise autometer. This acid is pronounced to be pure acetous acid, perfectly free from sulphuric and all other mineral acids, and from mucilaginous, earthy, and metallic impurities. It is therefore, when diluted, perfectly wholesome with food, and may be used for all the purposes of vinegar.

The Pyroligneous acid admits of being diluted with seven parts of water, which will reduce it to the strength of common distilled vinegar: it is then well qualified for pickling vegetables and fish; the latter, particularly, is found to be preserved longer with this vinegar, and to eat firmer and better than with any other. This acid is bright and colourless as water; but it readily takes any colour or flavour. It will keep for any length of time, in any climate, without losing its strength, or becoming ropy and thick, or mothery, as it is generally termed. At sea it is particularly useful for the scurvy; and for all medical purposes, it answers the uses of the best distilled vinegar.

178. *Milk Tree in South America.*

M. Humboldt and his companions, in the course of their travels, heard an account of a tree which grows in the valleys of Aragua, the juice of which is a nourishing milk, and which, from that circumstance, has received the name of *the cow tree.*

The tree in its general aspect resembles the chrysophyllum cainito; its leaves are oblong, pointed, leathery, and alternate, marked with lateral veins, projecting downwards, they are parallel, and are ten inches long. When incisions are made into the trunk, it discharges abundantly a glutinous milk, moderately thick, without any acridness, and exhaling an agreeable balsamic odour. The travellers drank considerable quantities of it without experiencing any injurious effects; its viscidity only rendering it rather unpleasant. The superintendent of the plantation assured them that the negroes acquire flesh during the season in which the cow-tree yields the greatest quantity of milk. When this fluid is exposed to the air, perhaps, in consequence of the absorption of the oxygen of the atmosphere, its surface becomes covered with membranes of a substance that appears to be of a decided animal nature, yellowish, thready, and of a cheesy consistence. These membranes, when separated from the more aqueous part of the fluid, are almost as elastic as caoutchouc; but at the same time they are as much disposed to become putrid as gelatine. The natives give the name of cheese to the coagulum, which is separated by the contact of the air; in the course of five or six days it becomes sour. The milk, kept for some time in a corked phial, had deposited a little coagulum, and still exhaled its balsamic odour. If the recent juice be mixed with cold water, the coagulum is formed in a small quantity only; but the separating of the viscid membranes occurs when it is placed in contact with nitric acid. This remarkable tree seems to be peculiar to the Cordilliere du Littoral, especially from Barbula to the lake of Maracaybo. There are likewise some traces of it near the village of San Mateo; and, according to the account of M. Bredmeyer, in the valley of Caucagua, three days' journey to the east of the Caraccas. This naturalist has likewise described the vegetable milk of the cow-tree as possessing an agreeable flavour and an aromatic odour: the natives of Caucagua call it the milk-tree.

SECTION IV.

BUTTER, CHEESE, &C.

179. Butter is an artificial preparation of cow's milk. The milk, either in its natural state or in that of cream, is agitated till all its unctuous particles are separated from the whey, and a soft consistent mass is formed *.

Greek authors frequently speak of milk and cheese, but do not mention butter: and the Romans, for six centuries, used it as a medicine. In modern times the art of making, improving, and preserving butter has kept pace with the unwholesome custom of eating this animal oil from an early period of infancy. Butter forms a considerable article of trade. 50,000 tons of butter are annually consumed in Lon-

* There are also vegetable butters made from palm oil, and the oil of the cocoa nut. The celebrated Park found, in Africa, a tree called by the natives shea, from the fruit of which a tolerably pure butter was procured.

don; of which the counties of Cambridge and Suffolk are said to furnish 50,000 firkins, each containing 56lbs. None, however, is equal to that produced in Essex, and known by the name of Epping butter.

180. Cheese is made from curdled milk, freed from the serum or whey, and afterwards dried for use. Cheese differs in quality, as it is made from new milk or from skimmed milk, from the curd which separates spontaneously upon standing, or that which is more speedily produced with runnet. There is also cheese from cream, which is fat and butyraceous, and does not keep long. Of all the cheese made in England, none is so esteemed as the Stilton.

These cheeses must be kept two years before they are properly mellowed for use in families. The making of what is called Stilton cheese is not confined to the Stilton farmers. Others in Huntingdonshire and even in Rutland and Northamptonshire, make a similar sort, which is sold under the name of Stilton. The double Gloucester is much esteemed. The goodness of Chedder cheese is said to be owing to the richness of the land; the same is the case with the Somersetshire and that of adjoining counties. Cheshire cheese is generally admired. A cheese is sometimes above a hundred pounds weight. To give a high colour to cheese, it is usual to put with the milk before it is turned, a little annotto. No cheese will look yellow without it, and though it is perfectly innocent, it does not add to the goodness of the cheese.

SECTION V.

MISCELLANEOUS RESOURCES AND DOMESTIC PROCESSES.

Locusts used as Food.

181. Diodorus Siculus and Strabo give an account of a nation of Ethiopia, who were in the constant habit of eating Locusts. This peculiar supply was their sole food; for they had neither herds nor flocks, and they were unacquainted with fishing, for

they lived at a great distance from the sea. The stature of this singular people was lower than that of other men; they were very meagre, and extremely black. Nevertheless, they were an active race, ana ran with amazing swiftness. But their lives were not of long duration, seldom exceeding 40 years.

In the spring, high west-winds drove from the desert to their quarter, Locusts of an extraordinary size, and remarkable for the squalid colour of their wings. So great was the number of these insects, that they were the only sustenance of these barbarians, who took them in the following manner. At a considerable distance from their habitations there was a wide and deep valley, which they filled with wood and wild herbs. When the cloud of Locusts appeared,—being driven by the wind—they set fire to the fuel, the smoke of which was so extensive as to stifle the Locusts who were crossing the valley; so that they fell in heaps on the ground. They, thus made large provision of these insects, and as their country produced great quantities of salt, they salted them to render them more palatable, and to preserve them until the next season.

It is well known, that to this day, many of the Ethiopians and Arabians use Locusts as food; and Dr. Hasselquist learned from a Sheik at Cairo, who had lived six years in Mecca, that when corn is scarce, the Arabians grind the Locusts in hand-mills, or stone mortars, and bake them into cakes,—using them in place of bread. He also said, that he has frequently seen Locusts used by these people even when there was no scarcity of corn; but in this case, they boil them, stew them with butter, and make them into a kind of fricassee; which, he said, is not disagreeably tasted, for he had sometimes partaken of this *dainty* dish out of curiosity.

Dr. Sparrman says, that Locusts afford a high treat to the Hottentots at a distance from the Cape of Good-Hope; more especially as they make their appearance only at the intervals of 8, 10, 15, or 20 years:—but then, they appear in incredible numbers, flying to the south, not suffering themselves to be impeded by any obstacle, but flying boldly on till they are drowned in the sea. Of the female Locusts, the Hottentots make a brown coffee-coloured soup, which acquires from the eggs a fat and greasy appearance. Dr. S. says, that "the Hottentots are highly rejoiced at the arrival of these Locusts, though they are sure to destroy every bit of verdure on the ground; but they make themselves ample amends for this loss, by falling foul on the animals themselves, eating them in such quantities, as in the space of a few days to get visibly fatter, and in better condition than before." The Moors hunt Locusts—fry them in oil and butter, and sell them publicly at Tunis, Bona, &c.

182. *Curious Devices in Pastry.*

Some ancient adepts in cookery inform us, that in former days, when good house-keeping was in fashion among the *English* nobility, they used either to begin or conclude their entertainments, and divert their guests, which such devices as the following ones.—A castle made in pasteboard, with gates, draw-bridges, battlements, and port-cullisses, all done over with paste, was set at one end of the table, in a large charger, with salt laid round about it, as if it were the ground, in which were stuck egg-shells full of rose, or other sweet waters, the meat of the egg having been taken out by a great pin. Upon the battlements of the castle were planted guns made of kexes, covered over with paste, and made into the form of cannons, and made to look like brass, by covering them with Dutch leaf gold; these cannons being charged with gunpowder, and trains laid, so that you might fire as many of them as you pleased at one touch.

The castle was set at one end of the table, then in the middle of the table they would see a stag made in paste, but hollow, and filled with red wine, and a broad arrow stuck in the side of him; this being also set in a large charger, with a ground made of salt, and egg-shells of perfumed waters, stuck in as before; then at the other end of the table they would have the form of a ship, made in pasteboard, and covered all over with paste, with masts, sails, flags, and streamers, and guns made of kexes, and covered with paste, and charged with gunpowder, with a train as in the castle: this also in a large charger, set up upright in, as it were, a sea of salt, in which are also stuck egg-shells full of perfumed waters; then betwixt the stag and castle, and stag and ship, were placed two pies, made of coarse paste and filled with bran, and washed over with saffron and yolks of eggs. When these were baked, the bran was taken out, a hole was cut in the bottoms, and live birds put into one, and frogs into the other, and then the holes closed up with paste, then the lids were cut neatly up, so that they might be easily taken off by the funnels, and adorned with gilded laurels. These being thus prepared, and placed in order on the table, first of all one of the ladies is persuaded to draw the arrow out of the body of the stag, which being done, the red wine issues out like blood out of a wound, and causes some small admiration in the spectators; which being done, after a little pause, all the guns on one side of the castle are, by a train, discharged against the ship, and afterwards the guns of one side of the ship against the castle; then having turned the chargers, the other sides are fired off, as if in a battle. This causing a great smell of powder, the ladies or gentlemen would take up the egg-shells of perfumed water, and throw them at one another. This pleasant disorder being pretty well laughed over, and the two great pyes still remaining untouched, some one or other will have the curiosity to see what is in them, and lifting off the lid of one pye, out jump the frogs; to the amusement of some and the dismay of others, and lifting up the lid of the other, out fly the birds, which will naturally fly at the light, and so put out the candles; and so with the leaping of the frogs below, and flying of the birds above, a surprising and diverting hurley-burley was caused amongst the guests in the dark; after which, the candles being lighted, the banquet was brought in, the music sounded, and the particulars of each person's surprize and adventures, furnished matter for diverting discourse.

183. *Clock for the Palate.*

That there is no limit to the fertility of inventive genius, is proved by the construction of a chronometer, indicating to the sense of *taste,* the time of day, or more properly speaking, of night.

M. de Villayer, a member of the Academy of Sciences, in the 17th century, previous to the construction of Repeating Watches, contrived a clock with a large dial, the figures of which were hollow: in these hollows he placed variously flavoured sweetmeats; and, when he wished to know the hour of the night, felt with his finger the position of the hand, and ascertained the hour by the taste of the sweetmeat.

184. *Appetite restored by Abstinence.*

King Henry VIII. hunting in Windsor forest, struck down, about dinner-time, to the abbey of Reading, where, disguising himself as one of the royal guards, he was invited to the abbot's table. A *sirloin* of beef was set before him, on which he laid to as lustily as any *beef-eater*. 'Well fare thy heart,' quoth the abbot, 'and here in a cup of sack I remember the health of his grace, your master. I would give a hundred pounds could I feed as heartily on beef as you do. Alas! my poor queazy stomach will scarcely digest the wing of a chicken.'

The king heartily pledged him, thanked him for his good cheer, and after dinner departed undiscovered. Shortly after, the abbot was sent for by a pursuivant, brought up to the Tower, kept a close prisoner, and fed on bread and water, terrified all the time at his situation. At last a sirloin of beef was set before him, on which his empty stomach made him feed most voraciously. In the midst of his repast, he was astonished at seeing the king come from a private closet, where he had placed himself to be an invisible spectator of the scene. 'My lord,' quoth he, 'instantly deposit your hundred pounds, or else no going hence all the days of your life. I have been your physician to cure you of your queazy stomach; and here, as I deserve it, I demand my fee.' The abbot paid the money, glad to escape so easily.

185. *Corpulency and a Complication of Disorders cured by Abstinence.*

The following case is related by Sir George Baker in the Medical Transactions.

Thomas Wood *, born on the 30th of November, 1719, of parents who were apt to be intemperate in their manner of living, was subject to various disorders particularly the rheumatism, until he attained

* He was by trade a miller, and went by the name of "the miller of Billericay."

the age of thirteen years. He then had the small pox in a favourable way, and from that time became healthy, and continued to have no complaints to the age of about forty-three years. From his attaining the state of manhood to this period, but especially during the latter part of the time, he indulged himself, even to excess, in fat meat, of which he used to eat voraciously three times a day; together with large quantities of butter and cheese. Nor was he more cautious with respect to strong ale, which was his common drink.

About his fortieth year he began to grow very fat; but, finding that he had a good appetite, and digested his food without difficulty, and that his sleep was undisturbed, he made no alteration in his diet. It was in his forty-fourth year that he first began to be disturbed in his sleep, and to complain of the heart-burn, of frequent sickness at his stomach, pains in his bowels, head-ache, and vertigo. He was sometimes costive, at other times in the opposite extreme; had almost constant thirst, a great lowness of spirits, violent rheumatism, and frequent attacks of the gout. He had likewise two epileptic fits; but the symptom which appeared to him to be the most formidable, was a sense of suffocation, which often came on him, particularly after his meals.

Under such a complication of diseases, every day increasing, he continued till the month of August, 1764. At this time, the Rev. Mr. Powley, a worthy clergyman in the neighbourhood, observing his very ill state of health, and the extreme corpulence of his person, recommended to him an exact regimen, and pointed out the Life of Cornaro, as a book likely to suggest to him a salutary course of living. This book convinced him that intemperance was the principal cause of all his complaints; he therefore determined to try whether, the cause being removed, the effects might not cease. However, he thought it prudent not to make a total change in his diet suddenly, and at once; accordingly, he at first confined himself to one pint only of his ale every day, and used animal food sparingly. This method he soon found to answer to his satisfaction; for he felt easier and lighter, and his spirits became less oppressed. These good effects encouraged him to proceed in his experiment; and, therefore, after he had pursued the regimen before mentioned, during two months, he deducted from his allowance half the former quantity of ale, and was still more sparing of gross animal food. In this course he continued till the 4th of January 1765, at which time he entirely left off all malt liquor; and in the following month he began to drink only water, and to eat none except the lighter meats. Under this degree of abstinence, although some of his complaints were relieved, yet some of them remained in full force. The rheumatism tormented him; and still he had, now and then, slight fits of the gout. On the 4th of June following he began the use of the cold bath, and continued it twice or thrice a week, until October 1767. About the same time he began the exercise of the dumb-bell; in which he persevered to the last. Water was his only drink from the same period, and he limited himself to two glasses and a half. He also, about the same period, left off butter and cheese; and the 21st of July, in the same year, was the last time of his eating any animal flesh. Since that date, his diet was principally confined to pudding made of sea-biscuit. He allowed himself very little sleep; generally going to bed at eight o'clock in the evening, sometimes earlier, and generally rising about one in the morning, but being very rarely in bed after two.

Under this strict course of abstinence he continued to live; and expressed, in the highest terms, the great pleasure and tranquillity of mind which he enjoyed in consequence of it. The poor diet to which he accustomed himself, now was as agreeable to his palate as his former food used to be; and he had the additional satisfaction to find his health established, his spirits lively, his sleep no longer disturbed by frightful dreams, and his strength of muscles so far improved, that he could carry a quarter of a ton weight, which he in vain attempted when he was about the age of thirty. His voice, which was entirely lost for several years, now became clear and strong. In short, to use his own expression, he was metamorphosed from a monster to a person of moderate size; from the condition of an unhealthy, decrepid old man, to perfect health, and to the vigour and activity of youth.

186. *Hydrophobia cured by the Root of Water Plantain.*

The Russian Counsellor of State, Lewshein, has lately published a report of a new remedy for this disease, of which the following is the substance:

The counsellor was told that an old soldier, living in a village in the circle of Belewsky, had frequently cured men and brutes who had been bitten by a mad dog. Having got some information on the subject, "I learnt," says he, "that he reduced into a powder a root similar to an onion; and that, after having strewed it on a slice of bread and butter, he gave it to the patients to eat; and I was assured that they were always cured by it. I gave little credit to it, until an accident furnished me with a proof of its efficacy. One of my brother's hounds went mad, and bit the huntsman: the ordinary operation was performed to prevent the propagation of the virus, the wound was healed, and we had no uneasiness on the subject; but in a few weeks all the symptoms of hydrophobia appeared, and we were obliged to confine the huntsman with great precaution. As there was no medical man in the neighbourhood, I advised the patient to be taken to the soldier. He administered two doses of his remedy, one in the evening, the other next morning, and then said that the man might be unbound and taken home without danger. The huntsman experienced great weakness, but he had no fits either of delirium or hydrophobia. In a few days he found himself perfectly cured, and he has now lived eighteen years without having any relapse. The soldier said that he learnt the remedy of a peasant of Archangel.

The *alisma plantago*, or water plantain, is the one which this man made use of. It grows in water marshes, lakes, and stagnant muddy pools: the root resembles an onion, with thick fibres. This plant remains under water till the latter end of May or the beginning of June; when in flower it has a head like asparagus. It is in flower all the summer, and may be gathered at any time; but the best is at the end of August. The roots are well washed and cleaned, and dried in the shade; when dry, it is pulverised, and administered as above. Two or three doses have been found sufficient to effect a cure, even after the hydrophobia is declared in the patient, whether it be men or animals, that have been bitten by mad dogs, in the cure of which it has scarcely ever been known to fail. Indeed, during the twenty-five years that it has constantly been practised in the government of Tula, no instance of failure, in an immense number of cases, has been known.

187. *Betel chewed by the Asiatics.*

The leaves of the betle, or betel, an Indian plant, alone, or prepared in the manner hereafter to be mentioned, are used to an almost incredible extent by the southern Asiatic nations, from Hindostan to the farthest confines of the Chinese empire, in the same manner, and for the same purposes, as opium is by the western. A great many virtues are ascribed to the betel by its votaries, the chief of which are the following: they believe, that it sweetens the breath; for which purpose, whenever the poorest sort are to appear before the rich, they chew a large quantity of betel; and it is held by them in such high estimation, that a box of prepared betel is the usual present on taking leave of their friends; that it preserves the gums, although it would appear to be injurious to the teeth, as it is not an uncommon thing to find people, of twenty-five, toothless in those parts of the world, from excessive indulgence in this plant. It is said also to be possessed of considerable tonic and other medicinal properties.

Prepared betel is composed of three different ingredients: viz. of the quarter of an areca or betel nut; of a betel leaf, in which the portion of the areca nut * is wrapped; and of the fine powder or chalk of calcined muscle-shells, which is sprinkled thinly over the betel leaf. People of all descriptions are provided with their boxes of prepared betel, which they present to each other by way of courtesy; and at visits it is handed about in the same manner as wine and coffee by the Europeans.

The chief time of using it is after dinner, when they say it prevents sickness; and, except on fasting days, or at the interment of relatives, its use is never abstained from. It has been observed, that few Europeans can habituate themselves to it: the sickness and intoxication which are frequently produced by betel, in those accustomed to it, are generally but of short duration.

The use of betel reddens the lips, and makes the teeth black; a colour which the Indians prefer to the whiteness admired by the Europeans.

188. *Penetrative Effects of the Effluvia from Peruvian Bark.*

In 1817, a French merchant, M. Delpech residing at Guayra, in the Caraccas, had stored up a

* The areca is a genus of palms, the nut of which, according to Dampier and Grose, frequently causes violent giddiness; but its effects are not so permanent as those of opium.

large quantity of fresh cinchona, in apartments which were afterwards required for the reception of some travellers as guests. These apartments contained each eight or ten thousand pounds of bark, and in consequence of its fermentation, the heat was much greater here than in the other parts of the house, rendering the place somewhat disagreeable. One of the beds placed in these rooms, was occupied by a traveller, ill of a malignant fever; after the first day he found himself much better, though he had taken no medicine; in a few days he felt himself quite recovered without any medical treatment whatsoever. This unexpected success induced M. Delpech to make some other trials: several persons ill of fever were placed successively in his magazine of cinchona, and they were all speedily cured, simply by the effluvia of the bark.

It happened that a bale of coffee and some common French brandy were kept in the same place for some months; one of the brandy bottles happened to be uncorked, and on examination it was found to possess a slight aromatic taste, to be more tonic and very superior to common brandy. The coffee also was much altered; when roasted it was more bitter than common coffee, and left in the mouth a taste similar to that of an infusion of bark.

189. *Poisons with their Symptoms and Antidotes.*

Substances.	*Symptoms.*	*Antidotes.*
Concentrated acids: the vitriolic, nitric, muriatic, oxalic, &c.	Burning pain, vomiting. Matter thrown up effervesces with chalk, or salt of tartar, or lime, or magnesia.	Calcined magnesia: one ounce to a pint of warm or cold water. A glassful to be taken every two minutes, so as to excite vomiting. Soap, or chalk and water; mucilaginous drinks afterwards, such as linseed-tea, or gum arabic and water.

Substances.	*Symptoms.*	*Antidotes.*
Alkalies: soda, ammonia, lime, &c.	Nearly the same: the ejected matter does not effervesce with alkalis, but with acids.	Vinegar and lemon juice: a spoonful or two in a glass of water very frequently; simply warm water.
Mercurial preparations: corrosive sublimate, &c. &c.	Sense of constriction in the throat: matter vomitted sometimes mixed with blood.	White of eggs: twelve or fifteen eggs beat up and mixed with a quart of cold water. A glass full every three minutes. Milk, gum-water, linseed-tea.
Arsenical preparations: white arsenic, &c. &c.	Extreme irritation, pain, sickness, and speedy death, if the poison be not soon counteracted.	Warm water with sugar, in large quantities, to excite vomiting. Lime-water, soap and water, pearl-ash and water, mucilaginous drinks.
Preparations of copper, brass, &c. verdigris, half-penec, pins, &c. &c.	Symptoms nearly the same as from mercury.	White of eggs: (*see under mercury,*) mucilaginous drinks.
Preparations of antimony: emetic tartar, &c.	Extreme sickness, with other symptoms of poison, as above stated.	Warm water, or sugar and water; afterwards a grain of opium, or fifteen drops of laudanum every quarter of an hour, for two or three times.
Nitre.	Obstinate vomiting, sometimes of blood, &c. &c.	The same as for arsenic, with the exception of lime-water and alkalies.
Phosphorus.	Like mineral acids.	Same treatment.
Lead: sugar of lead, goulard extract, &c.	Great pain in the stomach, with constriction of the throat, &c. &c.	Large doses of Glauber's or Epsom salts, in warm water.

Substances.	*Symptoms.*	*Antidotes.*
Opium, henbane, hemlock, nux vomica, deadly nightshade, berries, mushrooms, &c. &c.	Stupor, desire to vomit, heaviness in the head, dilated pupil of the eye, delirium, and speedy death.	Four or five grains of tartar emetic in a glass of water; if this does not succeed, four grains of blue vitriol, as an emetic. Do not give large quantities of water. After the poison has been ejected, give vinegar, lemon juice, or cream of tartar. Strong coffee also is useful.
Poison of the yellow-billed sprat.		Solution of sugar.

Opium and arsenic, it is well known, are poisons; and, as the effects of these, are often fatal before medical aid can be procured, it may not be improper to state briefly the principal antidotes to either. When poison of any kind has been swallowed, the immediate object should always be that of endeavouring to excite vomiting; but much time is often lost by waiting the operations of medical emetics, when the discharge from the stomach might be much more speedily effected by mechanical means. Let, then, the persons who are about the individual who has taken poison, force a feather, or a piece of stick, or any thing that can be immediately procured, down the throat, and thus continue to irritate the parts till vomiting is induced. Emetics are of course to be administered as soon as they can be procured, when the power of swallowing is not suspended. After the contents of the stomach have thus been discharged, it is of consequence to recollect that acids are the best correctives of opium, and alkalies of arsenic.

In the one case, that of opium, then, let vinegar or lemon juice, diluted with about an equal quantity of water, be freely and copiously administered: in the other, that of arsenic, let a solution of soap in water be made as strong, and poured down as quickly as possible. This last answers a double purpose, the alkali of the soap acting upon the acid of the arsenic, and thus destroying its virulence; and the oily principle of this material, liberated in some measure from its alkali, seems to lubricate the coat of the stomach, and thus at once to abate the inflammation already excited, and to defend the parts from the further influence of the poison.

190. *The Plague in the Time of Justinian, the Emperor.*

The following dismal relation of this dire calamity is given in the eloquent language of Mr. Gibbon. Ethiopia and Egypt have been stigmatized in every age as the original source and seminary of the plague. In a damp, hot, stagnating air, this African fever is generated from the putrefaction of animal substances, and especially from the swarms of locusts, not less destructive to mankind in their death than in their lives. The fatal disease which depopulated the earth in the time of Justinian and his successors, first appeared in the neighbourhood of Pelusium, between the Serbonian bog and the eastern channel of the Nile. From thence, having as it were a double path, it spread to the east over Syria, Persia, and the Indies, and penetrated to the west, along the coast of Africa, and over the continent of Europe.

In the spring of the second year, Constantinople, during three or four months, was visited by the pestilence; and Procopius, who observed its progress and symptoms with the eyes of a physician, has emulated the skill and diligence of Thucydides in the description of the plague of Athens. The infection was sometimes announced by the visions of a distempered fancy; and the victim despaired as soon as he had heard the menace and felt the stroke of an invisible spectre. But the greater number in their beds, in the streets, in their usual occupation, were surprised by a slight fever; so slight, indeed, that neither the pulse nor the colour of the patient gave any signs of the approaching danger. The same, the next, or the succeeding day, it was declared, by the swelling of the glands, particularly those of the groin, of the arm-pits, and under the ear; and, when these buboes or tumors were opened, they were found to contain a coal or black substance of the size of a lentil. If they came to a just swelling and suppuration, the patient was saved by this kind and natural discharge of the morbid humour. But, if they continued hard and dry, a mortification quickly ensued, and the fifth day was commonly the term of his life. The fever was often accompanied by lethargy or delirium; the bodies of the sick were covered with black pustules or carbuncles, the symptoms of immediate death; and, in the constitutions too feeble to produce an eruption, the vomiting of blood was followed by the mortification of the bowels. To pregnant women the plague was generally mortal.

Youth was the most pernicious season, and the female sex was less susceptible than the male; but every rank and profession was attacked with indiscriminate rage; and many of those who escaped were deprived of the use of their speech, without being secure from a return of the disorder.

The physicians of Constantinople were zealous and skilful, but their art was baffled by the various symptoms and pertinacious vehemence of the disease: the same remedies were productive of contrary effects, and the event capriciously disappointed their prognostics of death or recovery. The order of funerals and right of sepulchres were confounded; those who were left without friends or servants lay unburied in the streets, or in their desolate houses; and a magistrate was authorized to collect the promiscuous heaps of dead bodies, to transport them by land or water, and to inter them in deep pits beyond the precincts of the city. Their own danger, and the prospect of public distress, awakened some remorse in the minds of the most vicious of mankind, the confidence of health again revived their passions and habits. But philosophy must disdain the observation of Procopius, that the lives of such men were guarded by the peculiar favour of fortune or Providence. He forgot, or perhaps he secretly recollected, that the plague had touched the person of Justinian himself; but the abstemious diet of the emperor may suggest, as in the case of Socrates, a more rational and honourable cause for his recovery. During his sickness, the public consternation was expressed in the habits of the citizens, and their idleness and despondency occasioned a general scarcity in the capital of the East.

Contagion is the inseparable symptom of the plague, which, by mutual respiration, is transfused from the surfeited persons to the lungs and stomach of those who approach them. While philosophers believe and tremble, it is singular that the real danger should have been denied by a people most prone to vain and imaginary terrors (the French). Yet, the fellow-citizens of Procopius were satisfied, by some short and partial experience, that the infection could not be gained by the closest conversation; and this persuasion might support the assiduity of friends and physicians in the care of the sick, whom inhuman prudence would have condemned to solitude and despair. But the fatal security, like the predestination of the Turks, must have aided the progress of the contagion; and those salutary precautions, to which Europe is indebted for her safety, were unknown to the government of Justinian. No restraints were imposed on the free and frequent intercourse of the Roman provinces; from Persia to France the nations were mingled and infected by wars and emigrations; and the pestilential odour, which lurks for years in a bale of cotton, was imported, by the abuse of trade, into the most distant regions. The mode of its propagation is explained by the remark of Procopius himself, that it always spread from the sea-coast to the inland countries: the most sequestered islands and mountains were successively visited; the places which had escaped the fury of its first passage, were alone exposed to the contagion of the ensuing year. The winds might diffuse that subtle venom; but, unless the atmosphere be previously disposed for its reception, the plague would soon expire in the cold or temperate climates of the earth. Such was the universal corruption of the air, that the pestilence, which burst forth in the fifteenth year of Justinian, A.D. 542, was not checked or alleviated by any difference of the seasons. In time its first malignity was abated and dispersed; the disease alternately languished and revived; but it was not till the end of a calamitous period of fifty-two years that mankind recovered their health, or the air resumed its pure and salubrious quality. No facts have been preserved to sustain an account, or even a conjecture, of the numbers * that perished in this extraordinary mortality. I only find that, during three months, five, and at length ten, thousand people died each day at Constantinople; that many cities of the East were left vacant; and that, in several districts in Italy, the harvest and the vintage withered on the ground. The triple scourge of war, pestilence, and famine, afflicted the subjects of Justinian; and his reign is disgraced by a visible decrease of the human species, which has never been repaired, in some of the fairest countries of the globe.

191. *Effectual mode of Fumigating Letters infected with the Plague.*

The Portuguese government being anxious to prevent the importation of the plague: and not

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* It is probable that no less than an hundred millions of human beings fell victims to this contagion in the Roman empire alone!!!

wishing to adhere to the old system of opening the letters from foreign countries and soaking them in vinegar; commanded the junta of health to investigate some experiments to be made by Bernardino Antonio De Gomez, on the mode of disinfecting letters used and recommended by M. Morveau. The following narrative is in the experimentalist's own words.

His Excellency the Marquis de Foucas, M. le Desembargardor Bartholomeo Giraldes (first secretary of the Junta,) Luiz Antonio Rebello, doctors Joseph Pinheiso de Freitasloures, Henry Xavier Baeta, Ignatius Xavier, and myself, repaired to the chemical laboratory of the Mint, where the two following experiments were made.

First experiment.—Some opened letters were placed perpendicularly in a stove of Baumé, and they were exposed for five minutes to the action of the chlorine, developed according to the process of M. Morveau. On taking them from the stove, it was found, that the characters which were most proximate to the fumigating case, had assumed a yellowish hue, and the letters had a strong scent of the chlorine or muriatic acid.

Second experiment.—On treating a single letter in a similar manner, in which three parallel incisions were made, each an inch long, it was observed, that not only the envelope, but also the letter which had been taken out of it, always emitted the odour, which the fumigation had communicated to it, still less, however, than in the first experiment.

Having conveyed these letters to my house, I observed that they preserved for a long time the odour of the fumigation; and that this odour, in the letter enclosed in the envelope, was stronger for a few days, which followed that on which the experiment was performed, than on the day itself.

These two experiments, contrary to my expectation, appeared to support the resolution taken by the government; because the odour which was observed in the enclosed letter, indicated that it had penetrated to it, and the greater intensity of the odour in the opened letter, indicating, that the disinfecting process is more efficacious in the letters being opened, justifies, in a great measure, the order which was given to fumigate, by this method, the letters which are considered suspicious.

Under these circumstances, I considered it necessary to throw a greater light on the question by new experiments; not only because the importance of the case required it, but because the conclusions which my learned colleagues had drawn from those experiments, and their opinion, on opening the letters, did not agree with my own.

The letters not being all composed of half a sheet of paper, like that on which the second experiment was made, and as it might happen that they contained articles susceptible of infection, it was necessary to observe, what would be the result in letters more voluminous, and particularly in those in which materials, susceptible of the infection, were enclosed, in order to convince myself finally of the manner in which the chlorine penetrated the letters. To resolve these problems, I performed the following experiments in the laboratory of the Mint, for which purpose Doctor G. J. De Seixas, sub-director of the laboratory, furnished me with every assistance.

Third experiment.—I took two sheets of paper, and having folded them lengthways, I sealed them with wafers in a sheet of paper, and I made four transversal incisions in them, each an inch long; placing them obliquely in the stove, I caused the chlorine to develope itself underneath the grate, adding, at the same time, one ounce of common salt, two-eighths of manganese, four-eighths of water, and six-eighths of sulphuric acid. I suffered them to remain in the stove for fifteen minutes, and then breaking the seals, I conveyed them into another apartment, where Doctor Seixas, myself, and a servant of the laboratory, observed, that the sheets of paper smelt inwardly of the chlorine.

Fourth experiment.—I put in an envelope three sheets of paper, folded in two, and made three incisions in them of an inch long; and, after having proceeded in the same manner as in the former experiment, it was remarked, that the paper smelt sufficiently strong of the chlorine.

The result of these experimenss, and the observation which I made, that the letters which had been fumigated preserved for many days the odour of the chlorine, induced me to think, that the chlorine does not introduce itself into the letters only by the incisions. To ascertain this fact, the following experiment was made.

Fifth experiment.—I repeated the fourth experiment without making the incisions in the letter, and, on examining it afterwards, it was found to smell strongly of the chlorine; but the chlorine might have insinuated itself into the letter by the openings of the envelope.

Sixth experiment.—I repeated the fifth experiment, closing with the sealing-wax all the openings of the envelope in such a manner, that the letter appeared hermetically closed. It was observed, that the odour of the chlorine was perceptible in the paper, in a less degree, however, than in the letters in which the incisions had been made.

Seventh experiment.—I repeated the sixth experiment, by putting the letter in two envelopes, both being hermetically closed. The result was the same, and the odour was so determined, that my colleague and friend Dr. Pinheiro, in whose presence I opened the letter two days after the experiment, and who entertained great doubts of its efficacy, recognized the odour of the chlorine, and confessed that it had penetrated the paper.

If the chlorine extends its anti-contagious power, even to the infection of the plague, no doubt can be entertained that letters may be fumigated, according to the process of M. Morveau, without opening them, and without even making incisions in them. It must, nevertheless, be decided, how long the fumigation ought to continue, and under what particular circumstances it may be affirmed, that the suspected letters are disinfected by this process.

Eighth experiment.—In order to determine this essential point, according to the example of M. Morveau, I put six ounces of meat to putrify in a saucer; above the meat I suspended cotton, silk, hemp, wool, the feathers of the wing of the pea-hen, and a piece of fur; and I placed the whole in a glass receiver, surmounted with a cork. This apparatus was immersed in a bason containing water, half an inch in depth. When I had ascertained by means of the cork that the meat smelt sufficiently strong of putrefaction, I examined the materials above mentioned, and I recognized in all of them the bad smell of the meat. This smell was, however, stronger in the feathers and the skin, less strong in the silk and wool, and still less so in the cotton and the hemp.

I inclosed in twelve letters these six substances, infected with cadaverous odour. I made two incisions in each of these letters, of about an inch and a half. The fumigation was performed as in the third experiment, and after half an hour, the letters were taken from the stove. On examining immediately these six letters, which enclosed the six different infected substances, Doctor Seixas, the servant of the laboratory, and myself, were fully agreed, that the hemp only preserved the odour of the chlorine, that the cotton was absolutely free from it, that the feathers and the skin still smelt strongly of the putrefied flesh, and that the odour was weaker in the silk, and still weaker in the wool.

On examining the other six letters, on the following day, I observed, that the cotton and the hemp smelt of the chlorine, and not of the putrefied meat, the smell of which was scarcely perceptible in the silk and the wool, and still sufficiently determinate in the feathers and the skin.

I concluded, from this experiment, that the animal substances, at least feathers and skins, impregnate themselves more with the cadaverous odour than vegetable substances; that the latter lose it altogether, or are easily purified from it; that the effect of the fumigation is less at the close of the operation, than on preserving the letter sealed until the following day: finally, that animal substances require an action of greater duration and intensity than fumigation.

To verify this latter conclusion,

Ninth experiment.—I placed on a paper, pricked with a pin, these animal substances, infected with the cadaverous gas. I performed the fumigation on the outside of the stove, by suspending the paper two inches above the fumigating cup; in five minutes afterwards, the bad smell was not perceptible in any of them.

Tenth experiment.—I infected as in the ninth experiment, the same substances and the paper; the following differences were always apparent in this infection:—

First, there was not the half ounce of water, which in the ninth experiment moistened considerably the substances susceptible of infection.

Secondly, the bad odour was not so strong, supposing that it was either exhaled, its communication with the exterior air not having been intercepted by the water, or arising from some other cause, not at present to be defined.

The fumigation being performed, as in the ninth experiment, on all the substances, the paper produced the same result.

Eleventh experiment.—I performed the operation on letters containing paper, silk, wool, cotton, and hemp, infected by the same process. I allowed them to remain in the stove for one night; on the following day all those substances smelt of the chlorine, and had lost the cadaverous smell.

This experiment, in confirming the last conclusion of the eighth experiment, indicates, at the same time, a circumstance which ought to be observed in the disinfection of letters, according to the process of M. Morveau.

I ought, however, to premise, that either from the exhalation of the chlorine not being uniform, or the letters not being equally exposed to its action, the result of this process is not always the same. It might, therefore, happen, that in fumigating letters some may remain, in which the operation has been but badly or partially performed.

192. *Apparatus for the Production of Gas for Illumination, from Oil, &c.*

For the more general diffusion of the benefits arising from the use of Gas-lights, where houses and manufactories are at a distance from towns, and where coals are scarce, and room scanty; Messrs. Taylor and Martineau have invented and brought to great perfection, an apparatus whereby every purpose of economy is answered, and a most beautiful and splendid light is obtained merely from the distillation of impure oils, grease, &c.

A general idea of the process may be formed from the following account.

A quantity of oil is placed in an air-tight vessel, in such a manner, that it may flow into retorts which are kept at a moderate red-heat: and in such proportions, as may regulate the production of gas to a convenient rate, which may be easily governed by the will of the operator.

The oil, in its passage through the retorts, is decomposed, and converted into gas proper for illumination, having the great advantages of being pure and free from sulphurous contamination, and of supporting a very brilliant flame, with the expenditure of very small quantities. It will, however, generally be found that some oil passes off in the state of vapour, without being decomposed; and in order to condense this, and return it again into the oil vessel, the gas is made to pass through a vessel immersed in water, by which, and its exit by a worm, the vapour is condensed again into oil, and flows at once into the oil cistern, so as to come again into use in the retorts.

As a further precaution to purify the gas from oil, which may be suspended in it in the state of vapour, it is conveyed into a wash vessel, where by bubbling through water, it is further cooled and rendered fit for use; and passes by a proper pipe into a gasometer, from which it is suffered to branch off in pipes in the usual manner.

An apparatus, fit for a large establishment, and capable of producing from 1,600 to 1,800 cube feet of gas at one operation, requires only the cleaning out the retorts, which becomes necessary from time to time from the accumulation of a certain quantity of carbonaceous matter. This, and the necessary attention to keep up a moderate fire, is the only trouble which attends the use of the apparatus, and the time required for the production of the above quantity, would in general be about six hours.

The number of lights which would be supplied by 1,800 cube feet of oil gas, reckoning that they were argand burners, and employed for four hours, would be about 300, and giving a light equal to from 3,000 to 3,600 mould candles.

In order to adapt them to different establishments requiring smaller quantities of light, and to fit them for private houses, they may be made of various sizes, accommodated to different degrees of power, and suitable by the small space they occupy, for situations where much room cannot be spared.

One capable of furnishing gas for from 12 to 20 argand lights, may be conveniently placed in a small kitchen fire-place, and will occupy a space of four feet by three, and a height of about eight feet.

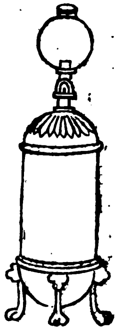
For private houses, a gasometer should not contain less than from 80 to 100 cubic feet, and for larger establishments, they should contain from 300 to 600. There are great advantages in having the gasometer as large as circumstances will admit; in the first place, the demand of the longest night in winter should be provided for, and the encreased consumption occasioned by lighting the greatest number of rooms for company. In the second place, both the trouble and expense of the gas is diminished by having a reservoir sufficiently capacious to hold some days' ordinary consumption, by which, as the gas improves by keeping, it is most convenient and economical to have to make it but once or twice a week.

In a private house, where three or four rooms are adequately lighted, and where a small flame is kept burning all night in a bed-chamber, it has been found that from 20 to 30 cube feet of oil-gas is sufficient; and, therefore, a gasometer containing 100 feet will give a supply for four nights.

Such a gasometer will be about six feet long and four wide, and rather more than four feet high. One for 400 cube feet may be 10 feet long, and seven wide, and about six high.

There is no occasion that a gasometer should be placed near the other parts of the apparatus.

193. *Account of Mr. Gordon's Portable Gas Lamp.*



The application of inflammable gas to the purposes of illumination, has hitherto been almost wholly confined to the lighting of large cities, extensive manufactories, and public institutions. The ingenious apparatus invented by J. and P. Taylor, for obtaining gas from oil, has enabled gentlemen of fortune to light their houses with gas at a moderate expence, and without being annoyed by any of the disagreeable products which arise from the distillation of coal. But notwithstanding this valuable improvement, gas light has never till lately been rendered portable, and the great body of private individuals, and all the lower classes of society, are unable at this moment to derive any advantage from the extraordinary cheapness of this beautiful light.

In order to remove these limitations to the use of gas lights, and to render them available in every case where lamps or candles can be used, Mr. Gordon conceived the idea of condensing a great quantity of gas into a small space, and set himself to construct a lamp, in which this condensed gas could be burned with the same facility and security as an ordinary lamp.

The body or reservoir of the lamp is commonly made of copper, about one-twentieth of an inch thick, in the form of a sphere or a cylinder, with hemispherical ends. This reservoir may be put into a different apartment from that which is to be illuminated, or may be concealed under the table, or, when it is required to be ornamental, it may be put into a statue, or the pedestal of a statue, or may be suspended.

In order to regulate the escape of the condensed gas, Mr. Gordon has employed two different contrivances, which are extremely ingenious. The first of these is a stop-cock, constructed in the following manner: after the cock has been drilled through in the usual manner, the circular hole in the key is contracted at one side, by soldering into it two pieces of brass, which join at one side of the hole, and are about one-twentieth of an inch distant at the other side, forming an acute angular aperture. By this means the issue of gas can be regulated to the smallest possible stream, by bringing the acute angle of the opening in the key to communicate with the circular opening in the cock; and as the expansibility diminishes as the gas is consumed, the aperture can be increased in the same proportion. But to secure the above object more completely, and to prevent the possibility of turning the cock suddenly, so as to admit too great a discharge of gas, a ratchet wheel is fixed in the end of the key of the cock, in which an endless screw works. By turning this screw the flame may be enlaged or diminished to any extent, however highly condensed the gas may be.

The second contrivance which Mr. Gordon employs to produce the same effect, is a conical leather valve, similar to that in the reservoir of an air-gun, placed in the opening of the reservoir of the lamp, where it screws on to the condensing pump. When the reservoir has been charged with gas, and removed from the pump, a piece of brass, is screwed in above the valve. Through this piece of brass there passes a finger screw, the point of which, when made to press on the valve, forces it back, and allows the gas to issue in any quantity that may be required. A bridge of brass, consisting of a hollow tube, in the form of a Gothic arch, passes over the head of this regulating screw, for the purpose of giving freedom to the fingers in turning the screw to regulate the flame, and to conduct the gas to the burner.

To force in the gas into each vessel separately, as the air is forced into the reservoir of an air-gun, would be attended with much inconvenience and expence. Not only is this sort of air-pump expensive, but it requires a degree of care to use it, and to keep it in repair, that could not be expected from common servants. To obviate this inconvenience, Mr. Gordon condenses the air in a large vessel of cast iron or copper, from whence it is drawn off into the small reservoir belonging to the individual lamp.

The application of this lamp to the lighting of private and public carriages, as well as to coal-mines, under the safeguard of Sir H. Davy's invention, will be speedily put in practice; and we hope the time is not very distant, when reservoirs of condensed gas shall be established in every town and village of Great Britain, and when the lonely cottages of the poor shall be enlivened by this economical and cheerful light. There is one application of the portable gas-lamp to which we attach a very high value. By an extreme diminution of the aperture, the flame can be rendered so small (in which case it is reduced to a blue colour) as to give no perceptible light, and to occasion almost no consumption of gas. In this state the lamp may be used in bed-rooms; and the imperceptible flame may at any time be expanded into the most brilliant light, by turning the cock, by means of a metallic rod terminating near the bed. The foregoing figure represents one of the portable gas-lamps, six inches in diameter and nine inches high, exclusive of the hemispherical ends and burner at the top; which, when filled with coal-gas condensed twenty-five times, will supply a lamp equal to five candles six to the pound for six hours; and, when filled with vegetable oil-gas, will burn for about twelve hours. A similar cylinder, six inches diameter and two feet high, exclusive of the hemispherical ends, is calculated to supply an argand burner, equal to ten candles, for six hours, with coal-gas, and for twelve hours with vegetable oil-gas.

194. *Experiments on the effects of Carbonic acid gas on Fruit.*

M. Dumont who made these experiments, thus relates them in a letter to Count Chaptal: " I put into separate white glass-jars four sorts of cherries, namely, sweet cherries, those of the kind called *English morellas, and bigarreaux cher-*

ries. I filled the jars with Carbonic acid gas obtained from lime and sulphuric acid, and put them in a cellar. The corks fitted but indifferently. At the end of a fortnight the colour and taste of the fruits were not sensibly altered. From about this period a liquid was deposited at the bottom of the vessel, and as it increased, the taste and colour of the cherries began to change. At the end of six weeks a strong smell of alcohol was perceived on inhaling the air from the vessels on opening the corks. The morellas had entirely changed colour, and in the toughness of the flesh, the adhesion to the stones, and the taste, resembled cherries infused in brandy, so as entirely to deceive several persons who tasted them. They remained unbroken.

The *bigarreaux* had undergone different degrees of change according to their ripeness: some remained entire, others had gone into a sort of marmelade. I distilled eleven pounds of them, and obtained about six ounces of good alcoho of 25 degrees. I did not distil the other fruits.

I treated in the same manner some *chasselas* grapes, some ripe, others beginning to turn, some from the neighbourhood of Paris, others from Fontainbleau. The jars were this time covered with wet bladder, and closely tied with packthread, and I kept them in my room. On the first day the bladders were depressed like a funnel, but afterwards they rose up again, swelled, and were strongly stretched by the contained air. One of them was shattered to pieces with a very loud explosion, which made me prick the others with a pin, and the gas rushed through the hole with force and hissing.

The grapes began to alter in their taste in about twenty days. Some of them became opake, and they all were harder, and had acquired a vinous flavour; those of Fontainbleau less than the others.

On the 29th of last October I cut in quarters four pounds of the *catiya* baking-pears, and enclosed them as before in a jar covered with bladder, and kept them in my room. A good deal of liquid gradually collected at the bottom of the jar, and the pears broke down into a pulp. I distilled them on the 6th of January following, placing them on a grate within the alembic, and adding a little water. I obtained thereby about four ounces of alcohol of 19 degrees.

On the same day I treated in the same manner, three pounds fifteen ounces of *chataigners* apples cut in quarters, but no liquid collected in the jar, and they gave no vinous taste when chewed.

On the 5th of last October, having received from the department *de l'Indre*, some chesnuts, of the kind called *pointed*, I filled two jars with them and carbonic acid gas as before. About a fortnight after they were taken out, husked, and boiled. I tasted them when hot, and found a slight alcoholic taste, which did not improve them; they were better cold. Some from the other jar taken from the surface, were completely preserved. They were roasted in hot embers, and had a kernel taste, which was also perceived when eaten raw. Another portion of these same chesnuts which was not kept in carbonic gas was soon spoiled.

SECTION VI.

SOAP, SODA, STARCH, CANDLES.

195. SOAP is composed of an alkaline salt, and animal or vegetable oil; it is sometimes dry and hard, at others, soft and liquid, according to the mode in which it has been manufactured. Where large quantities of soap are made, heat becomes indispensable; for this purpose a ley is made of barilla and quicklime, in the proportion of four parts of the former to one of the latter, and which must be sufficiently strong to bear an egg.

Equal parts of such ley, and tallow, or oil, are next poured into a copper, placed over a gentle fire, and continually stirred until they begin to unite, when the rest of the ley is added, and the agitation continued, till the ingredients are completely incorporated. The mixture is afterwards cast into proper vessels, at the bottoms of which a little pulverized chalk is spread, to prevent it from adhering, and in a few days the soap acquires a sufficient consistency to be taken out, and formed into oblong squares.

Common hard soap is prepared from the caustic ley, with the addition of tallow; the Venice, Alicant, or Spanish soap with olive oil: green soap with that of rape, hemp, or linseed; black soap with train oil; and lastly, the ordinary soft soap is formed by using pot-ash as a substitute for soda, together with tallow or train oil, and a large quantity of common salt.

Palm, violet, almond, or other soaps, are prepared in a similar manner; with the oils of vegetable substances. Soap, formed of tallow, is often adulterated by a strong brine, without impairing its hardness or consistency. A certain mode of detecting this fraud is, to expose a piece of soap to the air for several days: the water will evaporate, and the diminution in weight will at once detect the imposure.

196. Fuller's earth, a well-known mineral. When put into water immediately absorbs it, and breaks down into a fine pulp.

This earth is valuable for its property of taking grease out of woollen and other cloths, which, on a large scale, is effected by the operation called fulling, whence its name has been derived.

This, which is performed by a kind of water-mill, called a fulling-mill, is particularly necessary with respect to new cloths, for the purpose of depriving them of the grease and oil which has been used in their preparation.

In the dressing of cloth, it is so indispensable that foreigners, although they can procure the wool, are never able, without fuller's-earth, to reach the perfection of the English cloths; and in this country incalculable quanties of it are consumed. As an article of domestic utility, it might be more frequently used than it is for the cleaning and scouring of wooden floors and wainscots. In this respect it might be rendered an excellent substitute for soap.

There are extensive beds of this earth in several of the counties of England. London is principally supplied from those of Kent, Sussex, and Surry. We are informed that at Wavedon, near Woburn, in Bedfordshire, a peculiarly fine kind of fuller's-earth is dug up from pits at the depth of ten or twelve feet below the surface of the ground; and no country in the world is known to produce fuller's-earth of quality so excellent as England.

197. Soap-earth, a soft and unctuous substance, which has much the appearance of soap, is generally of a white or grey colour, intermixed with greenish or yellowish shades, and it is somewhat more than twice as heavy as water.

In the counties of Devon and Cornwall, and the islands in the vicinity of the Lizard Point, this mineral is found in considerable abundance. It possesses many of the same properties as fuller's-earth, and is in like manner employed in the scouring of woollen cloths. It may also be formed into a paste with water, and in this state is easily worked like clay for the manufacture of earthenware.

198. Soda is a mineral alkali, sometimes found in a native state, as in the lakes of Natron, in Egypt, which are dry in the summer season; the water leaving, after evaporation, a bed of soda, or natron, of two feet in thickness.

A marine plant, called the salsola soda, which grows among the cliffs, on the sea coast, seems to be endowed by nature with the property of decomposing the salt water, that is, of separating the muriatic acid from the soda, which latter it absorbs. This plant is collected by the Spaniards, and burnt for the manufacture of barilla. Soda is also procured in a still more impure state, by burning the sea weeds on our own shores, particularly in Scotland, from which kelp is produced. Few articles are of greater importance to the arts, manufactures, and domestic economy, than soda; it is indispensably necessary for making hard soap, and also forms an excellent substitute for this article. If a weak solution of soda be poured into foul bottles or casks, in which wine has been kept for some time, it will completely dissolve the tartarous crust formed on their inner surface. Boot tops, saddles, or bridles, may with this liquid be effectually cleansed, without affecting the original colour of the leather.

199. Potash is made in countries abounding in wood thus: the burnt ashes are put into a cistern with water, and a strong ley is made; after a time, the water holding the water in solution is drawn off, leaving the impurities behind. It is also prepared from kelp, salt, glass-wort, fern, and sea wrack. This article is much used in domestic purposes.

200. Starch. If a quantity of wheat-flour be made into a paste, and held under a small stream of water, kneading continually till the water runs off from it colourless, the flour is divided into two distinct constituents. A tough substance of a dirty-white colour, called gluten, remains in the hand. The water is at first milky; but soon deposits a white powder, which is known by the name of starch.

This article is, in many places, thus prepared. Pure wheat is put into tubs of water and exposed to the heat of the sun, to induce a proper degree of fermentation; the water being changed twice every day, for six or eight days; when properly softened and fermented, it is poured into canvas bags, which are worked or beaten on a board, placed over an empty vessel, to extract the mealy parts. When this vessel is filled with the liquid flour, a reddish fluid appears on the surface, which is carefully skimmed, and pure water added. The whole is then briskly agitated, and allowed to subside; as the sediment increases, the water is gradually drained off, and at length the starch is formed into cakes, which are cut into small pieces, and dried for use.

201. Candles. When the tallow has been weighed and mixed in due proportions, it is cut into small pieces, to accelerate the melting, and being properly melted and skimmed, a certain quantity of water is poured into it in proportion to the tallow: the water precipitates the remaining impurities. No water, however, must be thrown into the tallow designed for the three first dips, as the wick absorbs water. This would render the candles unfit for use, and cause them to crackle and sparkle.

The tallow thus melted is poured into a tub, through a coarse sieve of horse-hair, to purify it still more, and is used after having stood three hours. It will continue fit for use twenty-four hours in summer, and fifteen in winter.

The wicks of candles are made of spun cotton, which the tallow-chandlers cut into pieces of the length of the candle; and then put on the sticks for dipping.

When the tallow is in proper order, the workman takes three of the branches, and immerses the cottons suspended thereon into the vat: they are then hung on a frame to cool, after which they are dipped again till the candles are of a proper size. Good candles, consist of an equal quantity of sheep's and bullock's tallow: hog's tallow causes them to gutter, and gives an offensive smell, with a thick black smoke. The wick ought to be properly twisted, sufficiently dry and pure, else the candle will emit an irregular, inconstant flame.

202. Wax Candles. The wicks of these candles are made of cotton or flax, slightly twisted, and covered with white or yellow wax. Of these candles

there are several kinds; some conical, which are used in funeral processions, others cylindrical, used on ordinary occasions.

To make wax candles with a ladle, there is an iron circle from which a dozen wicks are suspended, at equal distances, over a large bason full of melted wax. A large ladle full of wax is poured gently on the tops of the wicks, one after another, till the candle arrives at its proper size. The three first ladles must be poured on the top, the fourth, fifth, and sixth, lower down, at certain distances, to give the candle its conical form. The candles are then taken down, and afterwards rolled and smoothed upon a walnut-tree table, with a long square instrument of box, smooth at the bottom.

When wax candles are made by the hand, the wax must be softened by working it in hot water, in a narrow, deep cauldron. A piece is then taken out and disposed by degrees round the wick.

Wax candles are either made as the former, with a ladle, or drawn. The latter are drawn as is wire, by means of two rollers of wood, turned by a handle, which pass the wick through melted wax contained in a brass bason, and at the same time through the holes of an instrument.

203. Mould candles are so called from their being made in moulds of tin. Each candle has its proper mould. A number of these moulds are placed in a table full of holes, and filled with melted tallow; and after the moulds have stood long enough to cool, the candles are drawn out, and sorted for use.

204. Rush-lights, used in different parts of England, are made of the pith of rushes, peeled, and dipped in melted grease.

205. Candle wood is made of slips of pine about the thickness of a finger, and is used in New England, and other places, to burn instead of candles, giving a very good light. Slips of yellow sandal-wood are used for the same purpose, and yield a clear flame, of a greenish colour.

SECTION VII.

SUGARS.

206. SUGAR seems to have been early known in India and China. Europe owes its knowledge of sugar to the conquests of Alexander; but it was not used as a food in Europe till after the discovery of America. Sugar in its pure form is one of the most nutritive substances derived from the vegetable kingdom; and is an excellent antiseptic, preserving from decay a multitude of organic substances. Almost all the sugar used in Europe is obtained from the sugar-cane, which grows in the West India islands, and elsewhere.

The canes are usually planted in pieces, cut a foot and a half below the top of the flower. They are ordinarily ripe in ten months, though sometimes not till fifteen, at which time they are found full of a white succulent marrow, whence is expressed the liquor of which sugar is made. When ripe and cut, they are carried to the mills, and are crushed between iron cylinders placed perpendicularly, and the juice runs through a little canal into the sugar house, which is near the mill, and is thence conveyed into a first copper, to receive the first preparation, which consists of heating by a slow fire. A quantity of ashes and quick-lime is here mixed with the liquor, to separate the unctuous parts from the rest, and by the heat, raise them to the top in a thick scum.

The same operation is carried on thrice, taking off the scum every time, and in this state it is called syrup. It is again boiled with lime and alum till concentrated, when it is poured into a cooler and stirred with wooden paddles which break the crust on the surface. It is afterwards put into hogsheads, whose bottoms are perforated, that the molasses with which the sugar is mixed, may be allowed to drain off. This process occupies about three weeks, and forms what is called raw or moist sugar. In Jamaica, the cane is productive, if a gallon of juice yield a pound of sugar.

207. Clayed or Lisbon Sugar. The process of claying is practised in St. Domingo, Guadaloupe, and Martinique. After the sugar has been prepared in the way just described, it is put into porous

earthenware conical pots, with the point in a jar; a cake of moist pipe-clay is placed on the base of the cone; the moisture passes through the sugar, and carries off the molasses; fresh clay is added three or four times, till the sugar becomes sufficiently clarified. The moisture of the sugar is also evaporated through the pores of the vessel. This is the process of refining the loaf-sugar.

208. Loaf Sugar. Lime water is poured upon the raw commodity, and bullocks' blood is added, in place of whites of eggs. The serum, or white part of the blood, becomes dissolved, but coagulates when hot, forming a gelatinous net work, which operates as a strainer, and carries upward all the opposing matters. The scum is skimmed off, and the sugar boiled with lime-water till it is transparent. Having acquired a proper consistence, it is poured into large coolers, and continually stirred with paddles, or oars, till it becomes opaque. When it has attained a sufficient degree of coolness, it is poured into moulds, made of earthenware, of a conical shape, and there stirred for some time, in order to disengage the air bubbles that are formed round the mass, and which would, otherwise, destroy the smoothness of the sugar-loaf.

The pots are then ranged in rows in warehouses, heated to a certain temperature, with the apex of the cone inverted into a jar; the base or broad part is covered with clay, fresh layers of which are applied three or four times: the water passes through the sugar, and carries away with it the molasses, forming a syrup, which again undergoes the same process as raw sugar. The loaves are now put in a stove to dry. Double refined sugar undergoes all the processes of the raw sugar, and the bluish-white cast sometimes observable is given by indigo.

209. Bastard Sugar, is of a dark brown colour, with the point or top of the loaf usually broken off. It is formed from the coarse syrup of fine sugar, and is generally ground under a mill-stone, and sold as powder-sugar.

210. Sugar-Candy, is composed of the particles of saccharine matter formed into large crystals, by slowly evaporating the clarified syrup.

The whole process is managed in strongly heated chambers, by the aid of vessels containing numerous threads, that intersect each other, and which are fastened to the sides in various directions; the sugar thus treated shoots into crystals round the threads, and according to its relative purity, the latter acquire a brown, yellow, or white colour.

211. Barley-Sugar, so called, because the sugar was formerly boiled with barley; but water now is generally used. It is first boiled till it be brittle, and then cast on a stone anointed with oil of sweet almonds, and formed into twisted sticks. Saffron is sometimes added, to give it the bright amber colour.

Sugar may be obtained from the following vegetable substances.

212. Maple. In North America, a very fine sugar is obtained from the acer saccharinum, or sugar maple. It is procured by boring the tree in the spring with an augur, and boiling the juice in the same manner as in the West India islands.

213. Beet-Root. Sugar has been obtained in Germany, in some quantity, from the beta vulgaris, or beet-root, but the practice does not appear to be very successful.

214. Grapes. In consequence of the loss of all her West India islands, France could not procure a sufficient supply for her own consumption, and large premiums were offered for the obtaining of sugar from grapes. This article, with a very fine flavour, is scarcely inferior to the West India sugar; and manufactories have been established on a very large scale for the making of sugar in this manner. The white grape yields 22 per cent. and the Spanish grape 33 per cent. of sugar, which is very good and fit for use.

215. Figs, dates, turnips, wheat, barley, beans, peas, currants, and apples, all contain sugar. This

saccharine quality is abundantly diffused over the vegetable kingdom, scarcely any plant being wholly destitute of it. The dew on the lime-tree will produce sugar, and three ounces of it may be obtained from twelve ounces of honey. Sugar is never found isolated, but is always combined with mucilage, &c. and may be extracted from alcohol.

216. *Manufacture of Sugar from Beet-Root in France :—Related by Count Chaptal.*

When France began to experience the want of sugar, its people at first sought for the means of supplying it in the syrups of certain fruits, especially the grape, and this manufacture has been singularly improved. Large establishments were formed in several parts of the kingdom for the extraction of syrup, and they have been productive of two important results, equally advantageous; first, of causing the consumption of a great quantity of syrup in the place of sugar for several domestic purposes, and exclusively in the hospitals; secondly, of giving a value to our grapes which at that period had scarcely any. A little time afterwards a method was found of extracting a farinaceous and solid sugar from the grapè, and this product was more similar to the cane sugar than the syrup; it was like the cane sugar in having no smell, and could be employed instead of it in every way, by using two or three times its weight to produce the same effect. This sugar is not susceptible of crystallization. Nearly at the same time, chemistry furnished the means of decolouring honey and depriving it of smell, so that it could be employed in the infusions of tea and coffee, as well as the best syrup of sugar.

All these processes were become domestic operations, and very little privation was suffered from the scarcity of cane sugar; but it was reserved for chemistry to produce in that climate the actual sugar of the colonies, and this was not long in coming to pass. Already the analyses of Margraff, and the important labours of Achard had put the French in the way; all now to be done was to improve the processes, and form a sufficient number of establishments to supply the demand. To effect this, the encouragement was prodigious, and in a single year we saw more than a hundred and fifty manufactories arise, some of which have proceeded with great success, and have poured into the market several million pounds of excellent sugar.

On the Culture and Preservation of the Beet-root.—It should be sown towards the end of March or in April, when there is no longer any fear of frost.

The most proper soil for the cultivation of the beet-root, is that which is both light and rich, and of a good depth. Poor, dry, and sandy soils are not at all suitable, for the beet comes up in such ground quite small and dry. Neither is stiff argillaceous soil proper for it. The seed comes up badly, especially if soon after it is sown a heavy rain happen to fall. Meadows newly ploughed and alluvial earths manured, and for a long time used, are very proper for the culture of this root. Good ground will furnish a hundred thousand of beet *per* hectare; I have even gathered as many as a hundred and twenty from a meadow newly ploughed; but the mean product is from forty to fifty thousand.

Beet-root during its Vegetation.—Perhaps there is no plant that suffers more from the vicinity of others than the beet-root; it remains small and without vigour if the ground be not carefully cleared of all the plants that spring up beside it.

In general the beet is gathered in the beginning of October, and the operation is terminated towards the fifteenth. The time of gathering is not a matter of indifference; but every one knows that, in the course of vegetation, there is formed a succession of different products which replace each other; so that the crystallizable sugar is contained in the beet-root only at a certain period of its vegetation, and this period is the time that must be chosen to gather it.

It appears, that, when the beet has terminated its saccharine vegetation, if I may so express myself, it forms nitrate of potash, at the expence of the constituent principles of the sugar: and this formation takes place in the ground, when it is assisted by the heat, just the same as it does in the store-houses.

As the beet-roots are pulled up, the leaves should be stripped off and left on the ground for manure, when there is not enough of them for the consumption of cattle.

In order to keep beet in a proper state, it should be stored in a dry place, of a temperature a few degrees above zero of the thermometer. It must not be stored up when wet; and, if the weather will permit, it is very desirable that it should be left for a few days in the fields to dry. It must not be covered up until frost is expected, and must be uncovered and left so as long as the temperature is a few degrees above freezing, provided it does not rain. It should be often examined, and if it appears to become heated, or decayed, or germinates, the heap must be opened, the injured roots separated from it, and then made up again.

On the Extraction of Sugar.—The most economical mode of washing is to put from 100 to 140lbs. into a cylinder composed of thick iron wire, half the cylinder being immersed in water contained in a trough under it; the cylinder is kept constantly turning round. In a little time the beet is freed from the dirt, the cylinder is then raised above the trough, a door which it contains is opened, and the beet slides down an inclined plane, which carries it beyond the trough.

I have no washing in my establishment; but I have the top and radicles cut off, and the surface of the roots, cleaned, all with a knife. This operation is executed with facility by women, and costs twelve sous, or sixty centimes *per* thousand.

The sugar is extracted by two successive operations. 1st. The beet is reduced to a pulp by means of graters: the best of these graters consist of cylinders, furnished on the surface with indented plates; these cylinders may be moved so rapidly, by means of wheels, that they will make 400 revolutions in a minute, and will tear and reduce the beet to a pulp in an instant. Two of these graters, put in motion by the same machinery, and attended by three women and two children are sufficient to grate daily 10,000 weight of beet, by working only four hours a day, two hours at a time; it is very rare that half an hour more is necessary.

In order that the pulp may be of a good quality it must have the appearance of a soft paste, without any lumps; for the press, however powerful, can extract but a very small proportion of juice from fragments of beet that have not been torn. When it is only crushed between mill-stones, in the manner that is practised for making cider and perry, the juice obtained from the press is not more than 30 or 40 *per cent.* whereas, when it is torn by the graters, from 65 to 75 *per cent.* is extracted. 2dly. As fast as the pulp is formed it is submitted to pressure, in order to extract the juice. I begin by putting it into small lever presses at first, and afterwards removing it to others more powerful, so as to extract from 65 to 75 *per cent.* of juice. The operation is perfect when the *marc* or dregs are so dry, that on squeezing it hard with the hands it does not wet them. To diminish the expence of manual labour, I place the graters and presses on a stage, in such a manner that the juice falls of itself, through leaden canals, into the boilers, which are placed on the ground. It is necessary that the pulp should be expressed as fast as it forms, or else it blackens, and a degree of fermentation commences, which renders the extraction of the sugar more difficult. The juice marks from five to eleven degrees, and commonly from seven to eight, by Beaumé's areometer.

I have before mentioned, that the juices run immediately out of the presses into a boiler, which I call a *depurator*, in relation to its use. Supposing two operations to be effected in a day, and that 5000 weight of beet-root is operated upon each time, this boiler, which is round, should be five feet and a half wide, and three feet eight inches deep; of these dimensions it will contain the whole product of one operation. As soon as the boiler is one-third, or half full, the fire is lighted. By the time that the juice has ceased running from the presses, it will already have acquired from forty to fifty degrees of heat, which is suffered to increase to sixty-five or, sixty-six degrees; and the moment it has attained this heat the fire is smothered by covering it with wet coals. Lime, slaked with warm water, is then thrown into the boiler, in the proportion of two grammes and a half (about forty-eight grains) to a litre of juice, being careful to vary the proportion according to the consistence of the juice. The liquid mass must be well stirred, in all directions, for some minutes, and then the fire is revived, in order to raise the heat to eighty degrees: that is, to the degree nearest approaching to ebullition. The fire is then taken out of the fire-place, and as the liquor cools a coat forms on its surface, which in half an hour has acquired a degree of consistence; which, at the end of three-quarters of an hour, is carefully taken off with the skim. As soon as it is skimmed, a cock is turned, which is fixed about a foot from the bottom of the boiler, and the liquor runs out into a square boiler; afterwards a second cock is opened, which is quite at the bottom of the boiler, in order to empty it entirely, and the liquor is made to fall upon a filter, through which it also runs into the square boiler.

The instant the liquor begins to boil, sulphuric acid, diluted with twenty parts of water, is poured into it, in the proportion of a tenth part of the lime employed; the whole must be well stirred, that it may be completely mixed: in order to ascertain that there is no excess of lime or of acid in the liquor, it may be tried upon paper coloured with turnsol or curcuma. It is best to suffer the excess of lime to remain, and to employ no more of the acid, the moment that it gives to the curcuma paper a tint of a pale brick or deep white-wine colour. After this operation, three *per cent.* of animal charcoal, well pounded to an impalpable powder, is mixed with the liquor, and immediately afterwards is added half of the charcoal that was used the evening before.

After the last addition of charcoal the liquid is evaporated, till it has acquired the consistence of from 18 to 20 degrees; it is then made to run into a smaller and deeper boiler, and is left at rest till the next day, when the boiling of the syrup is effected.

The Boiling and Refining.—The operation of boiling the syrup is the most delicate of any, but it has been rendered extremely easy by the improvements that have taken place in the preparatory operations, especially since the use of animal charcoal has been introduced. Many manufacturers have failed in boiling the syrup; and that which should be attributed to a bad manipulation, has generally been supposed to be owing sometimes to the non-existence of sugar in the beet, and sometimes to the almost insurmountable difficulty of extracting it. Now, this operation is become so easy that skim rises; it never burns during the boiling, and requires very little more care on the part of the workman who conducts it. Previous to the boiling, the concentrated juice made the evening before, and which still retains some degree of heat, is filtered through a coarse piece of woollen cloth; it is then poured into a round boiler, two feet in diameter and eighteen inches deep, till it is one-third full, and is then heated to ebullition, which is kept up to the end of the operation. If it chance to burn, it is perceived by puffs of white smoke, which come from the bottom of the boiler, and burst through the surface of the liquid, spreading a pungent smell; the fire must be slackened, the liquor stirred, and the operation more carefully attended to. The means of judging that the operation is going on well, are, when it boils dry and with noise; when the syrup detaches itself from the skimmer without drawing into threads, and without adhesion; when on striking the boiling mass with the back of the skimmer, the blow sounds dry, as if it struck upon silk; when it produces very little skim; when, on taking up some of the froth, or the bubbles out of the boil, with the skimmer, the bubbles disappear directly and resolve into liquid: this latter character distinguishes the bubbles of the boil from those of the skim; and, lastly, we may be satisfied that the operation has proceeded well, if no traces of black can be perceived at the bottom of the boiler, and the surface appears clean.

The time proper to terminate the boiling of the syrup may be known by working a drop between the fore-finger and thumb, till it has acquired the temperature of the skin, and separating the finger and thumb rapidly: when it begins to form a thread the operation is far advanced, and the experiment must be frequently repeated. The boiling must be discontinued the moment that the thread breaks dry. As soon as it is ascertained that the operation of boiling the syrup is completed, the fire is smothered, and a few minutes afterwards it is poured into the cooler, taking care to pour it high, that it may be mixed with air, for it is observed that this facilitates the crystallization.

In the evening, when the whole is collected in the cooler, the *forms* which are denominated *bastardes* are filled: the crystallization of the sugar immediately begins, and is almost always complete the next day; so that, in 24 or 48 hours after, it is put into the forms; these forms may, without inconvenience, be placed upon the pots for the melasses to run out.

To refine with alcohol, the operation must be commenced immediately as the melasses begin to run; for if any time is allowed for the sugar to dry, the melasses which moisten the crystals thickens, and forms a very hard coat upon the surface of the sugar, which the alcohol detaches with great difficulty: accordingly, the moment that the melasses begin to run, the surface of the sugar-loaf contained in the form is to be scraped, and a litre of alcohol at 36 degrees of commerce, poured by degrees over the whole surface, the little orifice of the form being stopped; the base of the form is then carefully covered to prevent the evaporation of the alcohol. In two hours the orifice of the form is opened, and the alcohol runs into the pot, charged with a great proportion of the colouring principle; the operation may be repeated with half the quantity of fresh alcohol, and the sugar is then equal in whiteness to the clayed or fine powder sugar. The sugar is then melted and put into the boiler with bullock's blood. The operation is terminated by either claying or alcoholising it again; but it has been observed, that the last mentioned gives the sugar a more heavy look than the other, and renders it a little more friable; for this reason I use alcohol for the first operation, and claying for the second. It is necessary to employ alcohol concentrated to 36 degrees; when it is weaker it dissolves a portion of sugar.

Expences and Product of a Manufactory.—The expences are comprised in the price of the beet, the manual labour for the extraction of the sugar, the interest of the sums spent in forming the establishment, the maintenance of the machines, the purchase of fuel, animal charcoal, and other less considerable articles.

The produce of ten thousand weight of beet-root is composed of three distinct parts—the sugar, the residuum or *mare* of the beet, and the melasses. In general, the beet furnishes from three to four *per cent.* of raw sugar, and sometimes even from four to five. The quantity varies according to the state of the weather and the expertness of those who work in the establishment. Besides the produce of the sugar, there is another which deserves consideration; this is the cuttings and the residuum of the beet after the juice is expressed from it. The residuum or *mare*, is a very valuable food for horned cattle and pigs.

The melasses is a third product not to be overlooked: a thousand weight of beet will produce nearly 240 pounds, which may be fermented and distilled in order to extract the alcohol. This alcohol has the peculiarity of being infinitely more pungent than any other at the same degree of concentration.

General Remarks.—Experience has also taught us, that the manufactories of sugar from beet-root can only prosper in the hands of proprietors who cultivate the plant themselves, and consume the residue upon their own demesne: indeed, it is only necessary to take a view of the advantages which this manufacture affords, when connected with a large farm, to be convinced of the great difference in the two cases.

This branch of industry, therefore, must be established on extensive property; for, independent of the advantages of situation, the erections necessarily depending on a large farm will mostly suffice, without any further expence, for the purposes of the new manufacture.

SECTION VIII.

COAL, SALT.

217. *Coal.*

This invaluable mineral is found in beds, or strata, frequently betwixt clay-slate and sand-stone, and seldom betwixt those of lime-stone. It chiefly occurs in the northern hemisphere, particularly in countries, which lie nearly in the same latitudes with Great Britain; in Siberia, Germany, Sweden, France, Canada, and Newfoundland; and in some of the northern parts of China. It is stated to be very abundant in New Holland; but we have no distinct account of coal in the continent of Africa. No fewer than seventy different kinds of coals are brought to the London market, the value and prices of which greatly differ. Of these the coals called *Wall's-end,* from the name of the pit, near Newcastle, whence they are obtained, usually bear the highest price.

Some kinds of coal are laminar, and others compact. They in general burn freely, with a bituminous odour, and leave a considerable residuum.

Some foreign writers have ascribed the great wealth possessed by this country to the coals which are here produced in such abundance, and which facilitate, in a very essential degree, nearly all its manufactures, and consequently are a means of promoting its commerce to an extent which is possessed by few other countries. All our great manufacturing towns, Birmingham, Sheffield, Leeds, Glasgow, &c. are situated either in the midst of coal districts, or in places to which coals are conveyed, with little expense, by canal carriage.

Coals are principally obtained from the neighbourhood of Newcastle-upon-Tyne, Sunderland, and Whitehaven.

The particular places whence they are produced have the name of *collieries*, and the mines from which they are dug are called *pits*. The deepest of these are in Northumberland, and are worked at more than 900 feet below the surface of the earth. At Newcastle there is a coal-pit near 800 feet in depth, and which, at that depth, is wrought five miles horizontally, quite across, and beneath the bed of the river Tyne, and under the adjacent part of the county of Durham. At Whitehaven the mines are of great depth, and are extended even under the sea, to places where there is above them sufficient depth of water for ships of great burthen, and in which it is said the miners are able sometimes to hear the roaring of the water. On the contrary, in some parts of Durham the coal lies so near the surface of the earth that the wheels of carriages lay it open, and in such quantity as to be sufficient for the use of the neighbourhood.

The beds of coal are of various thickness, from a few inches to several feet, and in some places it is found advantageous to work them at a very great depth, although their thickness does not exceed four or five feet. The thickest bed of English coal, of any extent, is that of the main coal in Staffordshire, which measures about thirty feet. There are frequently several beds above, and parallel to each other, separated by strata of slate, sand-stone, and other minerals. Coal is never found in chalk, and very rarely in lime-stone.

At Whitehaven the principal entrance to the coal-mine for men and horses is by an opening at the bottom of a hill, through a long passage hewn in a rock. This, by a steep descent, leads to the lowest bed of coal. The greatest part of the descent is through spacious galleries, which continually intersect other galleries; all the coal having been cut away, except large pillars, which, in deep parts of the mine, are three yards high, and about 12 yards square at the base; such great strength being there required to support the ponderous roof. There are three distinct and parallel strata of coal, which lie at a considerable distance above each other, and which have a communication by pits that are sunk between them. These strata are not always regularly continued in the same plane; the miners occasionally meet with veins of hard rock, which interrupt their further progress. At such places the earth on one side of the vein appears to have sunk down, while that on the opposite side has its ancient situation. In some parts it seems to have sunk fifteen or twenty fathoms: and in others not so much as one fathom. These breaks the miners call *dykes.* When they come to one of them, their first care is to discover whether the coal in the part adjoining be higher or lower than that in which they have been working; or, to use their own terms, whether it be cast down or cast up. For this purpose they examine attentively the mineral strata on the opposite side, to see how far they correspond with those which they have already passed through. If the coal be cast down, they sink a pit to it; but if it be cast up, the discovery of it is often attended with great labour and expence.

In general the entrance to coal mines is by perpendicular shafts, and the coals and workmen are drawn up by machinery. As the mines frequently extend to great distances horizontally beneath the surface of the earth, peculiar care is necessary to keep them continually ventilated with currents of fresh air, for the purpose not only of affording to the workmen a constant supply of that vital fluid, but also to expel from the mines certain noxious exhalations which are sometimes produced in them.

218. *Common Salt, or Muriate of Soda.*

Though found in some countries in a solid and massive state, it is for the most part an artificial preparation from sea-water, and from the water of salt lakes and brine springs. It consists of soda, in combination with muriatic acid.

Few productions either natural or artificial are in so much request as common salt. It is used for correcting the insipidity of food, by the inhabitants of nearly all countries. When applied in small quantities it accelerates the putrid fermentation; and in this case is considered to aid digestion, by promoting the decomposition of the aliments. In a larger quantity it has a contrary effect, and tends to preserve organic substances from corruption. Salt is used for glazing the surface of coarse earthenware; and is employed in several processes of dying. The decomposition of salt furnishes *spirit of salt* or muriatic acid.

When this substance is dug out of the earth it has the appellation of *rock salt;* and immense masses of it are found in different countries of the world. The most considerable as well as the most celebrated salt mines with which we are acquainted are those about five miles from Cracow in Poland; and it is supposed that they contain more salt than would be sufficient to supply the wants of the whole world for several thousand years. Many of the persons employed in them seldom see the light of day. They constitute a kind of subterranean republic, and are governed by regular and stated laws and rules of polity. The salt is taken from these mines in blocks, so large as sometimes to measure nine feet in length, four feet in width, and two or three feet in thickness. In the year 1780, the greatest depth to which the workmen had penetrated was about 320 yards, and the mass of salt was considered to be in some places more than 240 yards thick, and to extend at least three leagues.

Near the town of Cardona, about 50 miles north-west of Barcelona, in Spain, there is a mountain of salt, without cleft or crevice, 500 feet high, and nearly three miles in circumference; and at Northwich and Nantwich, in the county of Chester, there are salt-mines of great depth and extent. These are frequently visited by travellers, and are found amply to repay the trouble and inconvenience of descending into them. There are two principal beds of this substance; the upper one is about 42 yards below the surface, and 26 yards thick. This was originally discovered about a century and a half ago, in searching for coal. The lower bed has already been examined to the depth of forty yards without coming to the bottom.

A most remarkable circumstance, and deserving notice, in the Northwich mine, is the arrangement of the salt, giving rise to an appearance somewhat like a Mosaic roof and pavement, where it has been horizontally cut. The salt is compact, but it is arranged in round masses, five or six feet in diameter, not truly spherical, but each compressed by those that surround it, so as to have the shape of an irregular polyhædron. The large pit at Northwich offers a very singular spectacle when duly illuminated; it is a circle of nearly two miles in circumference; the roof is supported by massive pillars of salt, and the effect is heightened by the variety of colours which it presents.

Salt is made from *brine springs* in Cumberland, Staffordshire, Worcestershire, and Cheshire; but the kind most commonly used in England is that which is made from sea-water, and has consequently obtained the name of *sea-salt*. The mode of manufacturing it is very simple.

The water is first pumped into shallow reservoirs of earth, called salt-pans, or salterns. In these it remains exposed to the sun until a certain proportion of the water is evaporated, so as to leave it about seven times stronger than in its original state. It is then conducted by another pump into flat iron pans, eight or nine feet square, and as many inches deep. These being placed over a hot fire, the liquor or brine is boiled until nearly the remaining particles of water have passed off by evaporation, and nothing is left in the pans but salt. This is thrown together into proper vessels, for a few days, to drain, after which it is fit for use. In some countries the whole evaporation is performed by the heat of the sun; and in extreme northern climates, where the sun would not have sufficient power for the operation, a very different process is adopted. The water is suffered to freeze in the salterns, and that portion of it which continues uncongealed is so strongly saturated that it requires only a moderate heat to evaporate the remainder of the water, and to crystallize the salt.

Obs. The decomposition of salt furnishes the muriatic acid, or spirit of salt, of commerce.

Bay-salt is that which is produced from the evaporation of sea-water by the heat of the sun only.

The inhabitants of Cardona, in Spain, make of the rock-salt in their neighbourhood, various transparent articles, which they vend at a cheap rate. These, which consist of small altars, figures of saints, crosses, chandeliers, salt-cellars, &c. are as clear as crystal, and to all appearance as lasting. They are chiefly purchased by strangers, as curiosities, and are distributed over various parts of Spain and the south of France.

CHAPTER VII.

SCIENTIFIC EXPERIMENTS.

SECTION I.

PNEUMATIC EXPERIMENTS.

Preliminary Facts.

219. THE air is a fluid which we breathe: for it envelopes our globe, to a considerable height around it. Clouds and vapours float in it, and the whole is called the *atmosphere*. As it is possessed of gravity, like other fluids, it must press upon bodies in proportion to the depth at which they are immersed in it; and it also presses in every direction, in common with all other fluids.

It differs from other fluids in the four following particulars:—1. It can be compressed into less space than it naturally possesses.

2. It cannot be congealed or fixed, as other fluids may.

3. It is of a different density in every part upward from the earth's surface, decreasing in its weight, bulk for bulk, the higher it rises.

4. It is of an elastic, or springy nature, the force of its spring being equal to its weight.

People unacquainted with the principles of natural philosophy, would not suppose that the air by which we are surrounded, is a material substance, like other visible matter. Being invisible, and affording no resistance to the touch, it seems to them extraordinary, to consider it as a solid and material substance; yet a few experiments will convince them that it is really matter, possessing weight, and the power of resisting bodies that press against it.

Experiment 1.

220. Take a bladder that has not the neck tied, you may press the sides together, and squeeze it into any shape. Blow into this bladder, and tie a string fast round the neck: you cannot then, without breaking the bladder, press the sides together; you can scarcely alter its figure by pressure. Whence then arise those effects? when empty, you could press the bladder into any form; but the air with which it is filled, prevents this: the resistance you experience when it is filled with air, proves that air is matter.

Experiment 2.

221. We say, a vessel is empty when we have poured out of it the water it contained. Throw a bit of cork into a bason of water, put an empty tumbler over it, with the mouth downwards, force it down through the water; the cork will shew the surface of the water within the tumbler, and you will see that it will not rise so high within as without the glass; nor, if you press ever so hard, will it rise to the same level. The water is, therefore, prevented from rising within the tumbler, by some substance which occupies the inside. This substance is air.

Experiment 3.

222. Open a pair of common bellows, stop up the nozzle securely, you cannot shut the bellows, which seems filled with something that yields a little, like wool; unstop the nozzle, the air will be expelled, it may be felt against the hand, and the bellows will now shut.

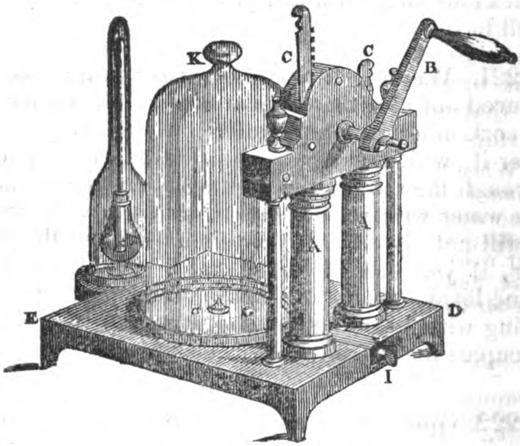
When the air is at rest, we can move in it with facility; nor does it offer a perceptible resistance, except the motion be quick, or the surface opposed to it considerable; but when that is the case, its resistance is very perceptible, as may be easily perceived by the motion of a fan.

When air is in motion, it constitutes *wind*, which is nothing more than a current or stream of air, varying in its force, according to its velocity.

The invisibility of air, therefore, is only the consequence of its *transparency;* but it is possessed of all the common properties of matter. We say a vessel is empty, in the usual way of speaking, when it is filled with air.

The mechanical properties of air.

223. But it is possible to empty a vessel of the air it contains, by which means we shall be able to discover several properties of this fluid. The instrument, or machine, by which this operation is performed, is called an Air Pump.



AA are two brass barrels, each containing a piston, with a valve opening upwards. They are worked by means of the winch B, which has a pinion that fits into the teeth of the racks CC, which are made upon the ends of the pistons, and by this means moves them up and down alternately.

On the square wooden frame D E, there is placed a brass plate, G, ground perfectly flat, and also a brass tube, let into the wood, communicating with the two cylinders and the cock 1, and opening into the centre of the brass plate at *a*.

The glass vessel K, to be emptied or exhausted of air, has its rim ground quite flat, and rubbed with a little pomatum, or hog's lard, to make it fit more closely upon the brass plate of the pump. These vessels are called *receivers.*

Having shut the cock 1, the pistons are worked by the winch, and the air being suffered to escape when the piston is forced down, because the valve opens upwards, but prevented from returning into the vessel for the same reason, the receiver is gradually exhausted, and will then be fixed fast upon the pump-plate. But opening the cock 1, the air rushes again into the receiver.

Experiment 4.

224. To demonstrate the weight of air by experiment, take a hollow copper ball, or other vessel, which holds a quart (wine measure), having a neck to screw on the plate of the air-pump, weigh it when full of air, exhaust it, and weigh it when empty; it will have lost 16 grains, the weight of a quart of air. But a quart of water weighs 14621 grains; this divided by 16, quotes 914 in round numbers; so that water is 914 times as heavy as air, near the surface of the earth.

When the receiver is placed upon the plate of the air-pump without exhausting it, it may be removed again with the utmost facility, because there is a mass of air under it that resists, by its elasticity, the pressure on the outside; but exhaust the receiver, thus removing the counter pressure, and it will be held down to the plate by the weight of the air upon it.

Experiment 5.

225. To determine what the pressure of the air amounts to. The surface of a fluid exposed to the air, is pressed by the weight of the atmosphere equally on every part, and remains at rest. If the pressure be removed from any particular part, the fluid yields in that part, and is forced out of its situation.

Into the receiver A put a small vessel with quicksilver, or any other fluid, and through the collar of leathers at B, suspend a glass tube, hermetically sealed, over the small vessel. Exhaust the receiver, let down the tube into the quicksilver, which will not rise into the tube as long as the receiver continues empty. Re-admit the air, the quicksilver will ascend. The reason is this, upon exhausting the receiver, the tube is likewise emptied of air; and therefore, when it is immersed in the quicksilver, the air re-admitted into the receiver, the surface of the quicksilver is pressed upon by the air, except that portion which lies above the orifice of the tube; consequently, it must rise in the tube, and continue so to do, until the weight of the elevated quicksilver presses as forcibly on that portion which lies beneath the tube, as the weight of the air does on every other equal portion without the tube.

Take a common syringe of any kind, and having pushed the piston to the farthest end, immerse it into water; draw up the piston, the water will follow, because, when the piston is pulled up the air is drawn out of the syringe with it, and the pressure of the atmosphere is removed from the part of the water immediately under it; consequently the water is obliged to yield in that part to the pressure on the surface.

Experiment 6.

226. Upon this principle those pumps called *sucking* pumps act: the piston fitting tightly the inside of the barrel, by being raised up, removes the pressure of the atmosphere from that part, and consequently the water is drawn up by the pressure upon the surface.

The pressure of the atmosphere is then the cause of the ascent of water in pumps; a column of water 33 feet high, is a counterpoise to one as high as the atmosphere. As mercury is fourteen times as heavy as water, a column of that fluid need only be $\frac{1}{14}$ of the length of one of water, to form an equal counterpoise to the pressure of the air; and accordingly, having filled with mercury a glass tube about three feet long, hermetically sealed at one end, invert it into a small bason of mercury, and the mercury will rise to the height of about 29½ inches, and there remain suspended, leaving at the top of the tube a space or perfect vacuum; the column of mercury varies in height, and consequently the pressure of the air is different at different times.

This phenomenon, too remarkable to be long unobserved, led to the observation that the changes in the height of the mercury were accompanied, or very quickly succeeded, by alterations in the weather. The instrument obtained the name of the *weather-glass*; from its also measuring the weight of the atmosphere, it is called the *barometer*, which is merely a tube filled with mercury, and inverted into a bason of the same, having a scale fixed at the top, to ascertain the rising and falling of the mercury, by the changes in the weight of the atmosphere.

Experiment 7.

227. Take a receiver open at the top, and cover it with your hand, exhaust the receiver, and thereby take off the pressure from the palm of the hand, you will feel it pressed down by an immense weight, so as to give pain that would soon be insupportable, and endanger the fracture of your hand.

Experiment 8.

228. If the top of the receiver be covered by a piece of flat glass, upon exhausting it, the glass will be broke to pieces by the incumbent weight; and this would happen to the receiver itself, but for its arched top, that resists the weight better than a flat surface.

This experiment may be varied, by tying a piece of wet bladder over the open mouth of the receiver, and leaving it to dry till it becomes as tight as a drum. Upon exhausting the receiver, you will perceive the bladder rendered concave, and it will yield more and more, until it break with a loud report, occasioned by the air striking forcibly against the inside of the receiver.

Experiment 9.

229. Air, one of the most elastic bodies in nature, is easily compressed into less compass, when the pressure is removed it regains its former bulk.

Let mercury be poured into a bent tube AB CD open at both ends, to a small height, as BC then stopping the end D with a cork, or otherwise, air-tight, measure the length of confined air DC, and pour mercury into the other leg AB, till the height above the surface of that in CD be equal to the height at which it stands in the barometer at the time. Then it is plain, that the air in the shorter leg will be compressed with a force twice as great as at first, when it possessed the whole space CD; for then it was compressed only with the weight of the atmosphere, but now it is compressed by that weight, and the additional equal weight of a column of mercury. The surface of the mercury will now be at E; and it will be found, upon measuring it, that the space DE, into which the air is now compressed, is just half the former CD.

If another column of mercury were added, equal to the former, it would be reduced into one-third of the space it formerly occupied. Hence the density of the air is proportional to the force that compresses it.

As all the parts of the atmosphere gravitate, or press upon each other, the air next the surface of the earth is more compressed and denser than what is at some height above it; in the same manner as wool thrown into a pit. The wool at the bottom having all the weight of what was above it, would be squeezed into a less compass; the layer, or stratum above it, would not be pressed so much; the one above that still less, and so on, till the upper one, having no weight over it, would be in its natural state. This is the case with the air, or atmosphere, that surrounds our earth, and accompanies it in its motion round the sun. On the top of lofty buildings, but still more on those of mountains, the air is less dense than at the level of the sea.

The height of the atmosphere has never yet been exactly ascertained; on account of its elasticity, it may extend to an immense distance, becoming rarer, in proportion to its distance from the earth. It is observed, that at a greater height than 45 miles, it does not refract the rays of light from the sun; and this is usually considered as the limit of the atmosphere. In a rarer state it may extend much farther. And this is by some thought to be the case, from the appearance of certain meteors which have been reckoned to be 70 or 80 miles distant, and whose light is thought to depend upon their coming through our atmosphere. A cubic inch of such air as we breathe, would be so much rarified at the altitude of 500 miles, that it would fill a sphere equal in diameter to the orbit of Saturn.

Experiment 10.

230. There is a contrivance for supporting a guinea and a feather, and letting them drop at the same instant. If let fall while the receiver is full of air, the guinea will fall quicker than the feather; but if the receiver be exhausted, they both arrive at the bottom at the same instant, which proves that all bodies would fall to the ground with the same velocity, if it were not for the resistance of the air, which impedes most the motion of those that have the least momentum, or weight.

In this experiment the observers ought to look at the bottom of the receiver, otherwise they will not be able to see whether the guinea and feather fall at the same instant.

Experiment 11.

231. Take a receiver, having a brass cap fitted to the top with a hole in it; fit one end of a dry hazel branch about an inch long, tight into the hole, and the other end tight into a hole quite through the bottom of a small wooden cup; pour quicksilver into the cup, exhaust the receiver, and the pressure of the outward air on the surface of the quicksilver will force it through the pores of the hazel, whence it will descend in a beautiful shower, into a glass cup placed under the receiver to catch it.

Experiment 12.

232. Put a wire through the collar of leathers on the top of the receiver, and fix a bit of dry wood on the end of the wire within the receiver; exhaust the air, push the wire down so as to immerse the wood in a jar of quicksilver on the pump-plate; this done, let in the air, and upon taking the wood out of the jar and splitting it, its pores will be found full of quicksilver, which the force of the air drove into the wood.

Experiment 13.

233. Set a square phial upon the pump-plate, and having covered it with a wire cage, put a close receiver over it, exhaust the air out of the receiver; in doing which, the air will also make its way out of the phial, through a small valve in its neck—when the air is exhausted, turn the cock below the plate to re-admit the air into the receiver; and as it cannot get into the phial again, because of the valve, the phial will be broken into pieces by the pressure of the air upon it. Had the phial been round, it would have sustained this pressure like an arch.

Experiment 14.

234. To shew the elasticity of air: tie up a very small quantity in a bladder, put it under the receiver; exhaust the air, the bladder (having nothing to act against it) will expand by the force of the air within it; upon letting the air into the receiver again, it will overpower that in the bladder, and press its sides close together.

If the bladder so tied be put into a wooden box, and have 20 or 30 pounds weight of lead placed upon it, and the box be covered with a close receiver; upon exhausting the air out of the receiver, that confined in the bladder will expand and raise up the lead by the force of its spring.

Experiment 15.

235. If a rat, mouse, or bird, be put under a receiver, and the air be exhausted, the animal will be at first oppressed as with a great weight, then grow convulsed, and at last expire in agonies. This experiment is too shocking to be practised, and we therefore substitute a machine called the *lungs-glass*, in place of the animal.

If a butterfly be suspended in a receiver, by a fine thread tied to one of its horns, it will fly about in the receiver as long as it continues full of air; but if the air be exhausted, though the animal will not die, and will continue to flutter its wings, it cannot remove itself from the place where it hangs, in the middle of the receiver, until the air be let in again, and then the animal will fly about as before.

Experiment 16.

236. Put a cork into a square phial, and fix it in with wax or cement; and put the phial on the pump-plate with the wire cage, and cover it with a close receiver; then exhaust the air out of the receiver, and the air that was corked up in the phial will break it outwards by the force of its spring, because there is no air left on the outside of the phial to act against that within it.

Experiment 17.

237. Put a shrivelled apple under a close receiver, exhaust the air, the spring of the air within the apple will plump it out, and cause the wrinkles to disappear; but upon letting the air into the receiver again, to press upon the apple, it will return to its former shrivelled state.

Take a fresh egg, cut off a little of the shell and film from its smaller end, put the egg under a receiver, and pump out the air; all the contents of the egg will be forced into the receiver, by the expansion of a small bubble of air contained in the greater end, between the shell and film.

Experiment 18.

238. Put some warm beer into a glass, set it on the pump, cover it with a close receiver, and then exhaust the air; the air therein will expand itself, and rise up in innumerable bubbles to the surface of the beer; and thence it will be taken away with the other

air in the receiver. When the receiver is nearly exhausted, the air in the beer, which could not disentangle itself quick enough to get off with the rest, will now expand itself so as to cause the beer to have all the appearance of boiling; and the greatest part of it will go over the glass.

Experiment 19.

239. Put some water into a glass, and a bit of dry wainscot or other wood into the water; cover the glass with a close receiver, and exhaust the air; the air in the wood, having liberty to expand itself, will come out plentifully, and make the water to bubble about the wood, especially about the ends, as the pores lie lengthwise. A cubic inch of dry wainscot has so much air in it, that it will continue bubbling for nearly half an hour together.

Experiment 20.

240. Let a piece of cork be suspended by a thread at one end of a balance, and counterpoised by a leaden weight, suspended in the same manner, at the other. Let this balance be hung to the inside of the top of a large receiver; set it on the pump, and exhaust the air, the cork will preponderate, and shew itself to be heavier than the lead; let in the air again, the equilibrium will be restored.

The reason is, since the air is a fluid, and all bodies lose as much of their absolute weight in it as is equal to the weight of their bulk of the fluid, the cork being the larger body, loses more of its real weight than the lead; and therefore must be heavier, to balance it under the disadvantage of losing some of its weight. This disadvantage being taken off by removing the air, the bodies gravitate according to their real quantities of matter, and the cork which balanced the lead in air, shews itself to be heavier when in vacuo.

Experiment 25.

241. Set a lighted candle upon the pump, cover it with a tall receiver. If the receiver hold a gallon of air, the candle will burn a minute; and having gra-

dually decayed from the first instant, it will go out; which shews that a constant supply of fresh air is as necessary to feed flame, as to support animal life.

The moment the candle goes out, the smoke will ascend to the top of the receiver, and form a cloud; upon exhausting the air, the smoke will fall down to the bottom of the receiver, and leave it clear at the top. This shews that smoke does not ascend on account of its being positively light, but because it is lighter than air; and its falling to the bottom when the air is taken away, shews that it is not destitute of weight. So, most sorts of wood ascend or swim in water; and yet there are none who doubt of the wood's having gravity or weight.

Experiment 22.

242. Set a receiver, open at top, on the air-pump, cover it with a brass plate and wet leather; having exhausted it of air, let the air in again at top through an iron pipe, making it pass through a charcoal flame at the end of the pipe; when the receiver is full of that air, lift up the cover, and let down a mouse or bird into the receiver, the burnt air will immediately kill it. If a candle be let down into that air, it will go out directly; but by letting it down gently, it will drive out the impure air, and good air will get in.

Experiment 23.

243. Set a bell on the pump-plate, having a contrivance so as to ring it at pleasure, and cover it with a receiver; then make the clapper strike against the bell, and the sound will be very well heard; exhaust the receiver of air, if the clapper be made to strike ever so hard against the bell, it will make no sound. This shews that air is absolutely necessary for the propagation of sound.

Of Condensed Air.

244. We now proceed to shew that the air can be condensed, or pressed into less space than what it generally occupies by an instrument called a *condenser*.

It consists of a brass barrel containing a piston, which has a valve opening downwards, as the piston is raised, the air passes through the valve; as the piston is pushed down, the air cannot return, and is therefore forced through a valve at the bottom of the barrel, that allows it to pass into the receiver, but prevents it returning. At every stroke of the piston, more air is thrown into the receiver, which is of very thick and strong glass. The receiver is held down upon the plate, by a bar, firmly screwed to two upright props, and the air is let out of the receiver by a cock.

A great variety of experiments may be performed, by means of condensed air. Thus the sound of a bell is much louder in condensed than in common air; and a phial that would bear the pressure of the common atmosphere, when the air is exhausted from the inside, will be broken by condensing the air round it.

The Air-Gun.

245. This pneumatic instrument will drive a bullet with great violence, by means of condensed air, forced into an iron ball by a condenser; but if the ball be not very good, it is apt to burst and injure the operator. In 1820 a man was killed in Yorkshire by the bursting of the air ball of an *air gun*.

There are many contrivances used in contructing air-guns; some have a small barrel contained within a large one; and the space between the two barrels serves for the reception of condensed air. The magazine-air-gun differs from the common one, only by having a serpentine barrel, which contains 10 or 12 balls: these are brought into the shooting-barrel successively, by means of a lever; and they may be discharged so fast as to be nearly of the same use as so many different guns.

SECTION II.

HYDRAULIC EXPERIMENTS.

Preliminary Facts.

246. The method of estimating the swiftness and the force of fluids in motion, is called Hydraulics.

You must have observed, an open vessel of liquor upon its stand, pierced at the bottom; the liquor, when the opening is first made, spouts out with great force; as it continues to run, it becomes less violent, and the liquor flows more feebly. Hydraulics instructs us in the cause of this diminution of the strength of the fluid in flowing; it will shew precisely how far the liquor will spout from any vessel, and how fast, or in what quantity.

Upon the principles of this science machines, worked by water, are constructed; as are engines used in the mechanic arts, as mills, pumps, and fountains, the result of this theory.

Experiment 1.

247. If a hole be made in the side of a vessel, the water will spout out, because fluids press equally in all directions. And the velocity with which water spouts out of a hole, in the side or bottom of a vessel, is as the square of the depth of the hole below the surface of the water: in order therefore to make double the quantity of a fluid run through one hole as through another of the same size, it requires four times the pressure of the other, and therefore the aperture must be four times the depth of the other below the surface of the water; for the same reason, three times the quantity running in an equal time through the same sort of hole, runs with three times the velocity, which will require nine times the pressure, and consequently the hole must be nine times as deep below the surface of the fluid, and so on.

Experiment 2.

248. Let two pipes of equal sized bores, be fixed into the side of a vessel, one pipe being four times as deep below the surface of the water in the vessel, as the other; and whilst the pipes run, let water be poured constantly into the vessel, to keep it always

full. Then, if a cup that holds a pint, be placed to receive the water that spouts from the upper pipe, and at the same moment a cup that holds a quart, be placed to receive the water from the lower pipe, both cups will be filled at the same time by their respective pipes.

Experiment 3.

249. The horizontal distance to which a fluid will spout from a horizontal pipe in any part of the side of an upright vessel, below the surface of the fluid, is equal to twice the length of a perpendicular to the side of the vessel, drawn from the mouth of the pipe to a semicircle described upon the altitude of the fluid: and therefore the spout will be to the greatest distance possible from a pipe whose mouth is at the centre of the semicircle; because a perpendicular to its diameter (supposed parallel to the side of the vessel) drawn from that point, is the longest that can possibly be drawn from any part of the diameter to the circumference of the semicircle.

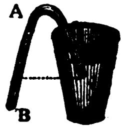
Obs. Fluids may be conveyed over hills and through valleys in bended pipes, in consequence of their measure, though they will not rise in any instance without mechanical force, to a height greater than the level whence they flow. The ancients, ignorant of this principle, constructed aqueducts, for the conveyance of water to cities. These aqueducts were rows of arches, one above another, between two hills, at an immense expence of money, time, and labour, in order to convey water over them, across the valley. This is now done by a range of pipes laid down one hill and up the other.

Experiment 4.

250. *The Syphon.*

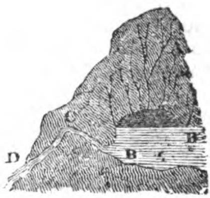
A Syphon, generally used for decanting liquors, is a bended pipe, whose legs are of unequal lengths, as A B.

If a small bent tube, whose legs are of equal length, be filled with water, and D turned downwards, the fluid N will remain suspended therein, so long as it is held level; but when an inclination is given to either leg, the perpendicular altitude of one is then made shorter than the other, and the water will flow from the lowest leg till the vessel is emptied,



The theory of this is as follows: the air is a fluid, whose density near the surface of the earth is experimentally found to be to that of water, at a medium, as 1 to 914; so that 914 gallons of air, near the earth, weigh as much as one gallon of water. Now, according to the nature of all other fluid bodies, the air presses the surface of all things exposed to it every way equally. When, therefore, the legs of the syphon, equal in length, are turned down, the weight of the atmosphere above being kept off by the machine, the under air, bearing against and repressing the water, which tends to fall out of both of them with equal force, keeps it in suspense, and prevents its motion; but when, by inclining it to either side, we in effect shorten one of its legs, and lengthen the other in perpendicular altitude, the balance is destroyed, and the longest will preponderate, as A B.

251. Upon the principle of the syphon also, we account for *intermitting* or *reciprocating springs*. Let A be part of a hill, within which there is a cavity B B, and from this cavity a vein, or channel, running in the direction B C D.



The rain that falls upon the side of the hill, will sink and strain through the small pores and crevices in the hill, and fill the cavity B B with water. When the water rises to the level of C, the vein B C D will be full, and the water will run through it as a syphon, and will empty the cavity B B. It must then stop, and when the cavity is again filled, it will begin to run again.

Experiment 5.

252. We have seen, that water will rise through bended pipes, to the same level as the reservoir from which it proceeds. Upon the same principle, *jets*, or *fountains*, are formed.

If near the bottom of a vessel, you fasten a small pipe, bending upwards, the water will spout out through the pipe, and rise nearly as high as the surface of the water in the vessel. It will not rise quite so high, because it is somewhat impeded by the resistance of the air, and the friction against the opening of the pipe, or adjutage.

It is always found necessary to increase the bore of the adjutage, or spouting-pipe, with the height of the reservoir; for if too small, the rising stream will want sufficient power to divide the air; which being densest near the earth, a small stream of water, endeavouring to mount to a great height, will be dashed against it with so much violence, as to fall away in a mist.

There is a fit proportion to be observed between the adjutage whereby the jet is delivered, and the pipe conducting it from the head. In general, about five times the diameter of the adjutage, for jets under half an inch, and six or seven times for all above, will give the size of conduct pipes pretty well; though it will always be an error on the right side, to have them rather larger than in strictness they ought to be, that the jet may always be freely supplied with water, and in due time.

For a like reason, if there be occasion for a cock to be placed in any part of the pipe of conduct, care must be taken, that it be there bigger in proportion, that the water may not be pinched, but that the cavity be left equal to the bore of the rest of the pipe.

The bore of an adjutage cannot be too smooth, or true. The cylindrical are best; the conical, worst.

SECTION III.

HYDROSTATIC EXPERIMENTS.

Experiment 1.

253. These experiments have reference to the weight and equilibrium of fluids. If from a balance you suspend an empty phial, corked, and loaded to sink in water, and counterpoise it by an equal weight in the opposite scale, when it is immersed in the water;

then, pull out the cork, and the water will rush in and fill the phial, but the equilibrium of the balance will be destroyed; and it will require as much weight to restore the equilibrium, as the real weight of the water in the phial; thus proving, that the water in the phial lost none of its weight by being surrounded by a fluid of the same kind.

Though fluids are subject to the same laws of gravity with solids, their want of cohesion occasions some peculiarities. The parts of a solid are so connected together, as to form but one and the same whole; and their effort is, concentrated in a single point, called the centre of gravity. The parts of fluids on the contrary gravitate independently of each other. And hence it is, that the surface of a fluid contained in an open vessel is always level, or parallel to the horizon.

Fluids have this remarkable property, that they press not only in common with solids perpendicularly, but also upwards, sideways, and in every direction equally.

Experiment 2.

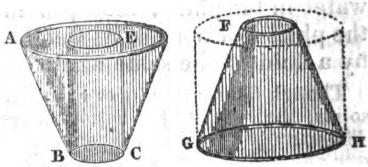
254. Take a glass tube open at both ends, stop one end with your finger, immerge the other in water. The water will be prevented from rising far in the tube by the air it contains, but take away your finger from the upper end, the air within the tube will escape, and the water will rise in the tube to the same level as it is in the vessel, being pressed upwards by the surrounding water. The same effect will take place, if you incline the tube in any direction, or if you make use of bent tubes, still you will find that the water within them will rise to the same height as in the external vessel. From this property it is, that if you bore a hole in the side of a vessel filled with water, the fluid will spout out.

Experiment 3.

255. A fluid presses in proportion to its perpendicular height, and the base of the vessel containing it, without any regard to the quantity. For as fluids press equally in every direction, the horizontal bot-

tom of a vessel sustains just the pressure of a column of the fluid, whose base is the area of the bottom of the vessel, and whose perpendicular height is equal to the depth of the fluid.

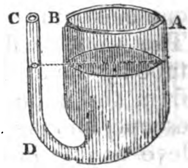
Thus, in the vessel AB, the bottom BC does not sustain a pressure equal to the whole quantity of fluid contained in the vessel, but only of a column whose base is BC and height CE. Also in the vessel FG, the bottom GH sustains a pressure equal to what it would be if the vessel were as wide at the top as the bottom.



Experiment 4.

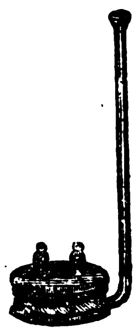
256. This leads to what is called the *hydrostatical paradox*, which is, that a small quantity of fluid may be made to counterpoise the greatest quantity.

Thus, if to a wide vessel AB, you attach a tube CD communicating with the vessel, and pour water into either of them, it will always stand at the same height in both, consequently there is an equilibrium between them. And of whatever shape the vessels are, the effect will be the same.



Experiment 5.

257. The *hydrostatic bellows* is a machine that demonstrates the upward pressure of fluids. It consists of two thick oval boards, each about 16 inches broad, and 18 inches long, covered with leather, to open and shut like a common bellows, but without valves; only a pipe about three feet high is fixed into the bellows.



Pour some water into the pipe, and it will run into the bellows, separating the boards a little: then lay three weights, each weighing 100 pounds, upon the upper board, and pour more water into the pipe, which will run into the bellows, and raise up the board with all the weights upon it; and, if the pipe be kept full, until the weights are raised as high as the leather which covers the bellows will allow them, the water will remain in the pipe, and support all the weights, even though it should weigh no more than a quarter of a pound, and they 300 pounds: nor will this weight cause the boards to descend, and force the water out at the top of the pipe.

The reason of this will appear evident, by considering what has been already said of the result of the pressure of fluids of equal heights, without any regard to the quantities. For, if a hole be made in the upper board, and a tube be put into it, the water will rise in the tube to the same height that it does in the pipe; and would rise as high (by supplying the pipe) in as many tubes as the board could contain holes. Now, suppose only one hole to be made in some part of the board, of an equal diameter with the bore of the pipe, and that the pipe hold just one quarter of a pound weight of water; if you put your finger upon the hole, and the pipe be filled with water, you will find your finger pressed upward with a force equal to a quarter of a pound; and as the same pressure is equal upon all equal parts of the board, each part whose area is equal to the area of the hole, will be pressed upward with a force equal to that of a quarter of a pound: the sum of all these pressures against the under side of an oval board 16 inches broad and 18 inches long, will amount to 300 pounds; and therefore, that much weight will be raised up, and supported by, a quarter of a pound of water in the pipe.

Hence, if a man stand upon the upper board, and blow into the bellows through the pipe, he will raise himself upward upon the board; and the smaller the bore of the pipe is, the easier will he be able to raise himself. And if he put his finger on the top of the pipe, he may support himself as long as he pleases, provided the bellows be air-tight.

Experiment 6.—*Of Specific Gravities.*

258. By the *specific gravities* of bodies is meant the relative weights, which equal bulks of different bodies have to each other. It is usual to compare them with that of water, as it is by weighing bodies in water, that their specific gravities are found.

The method of ascertaining the specific gravities of bodies, was discovered by Archimedes in the following manner:

Hiero, king of Syracuse, having given a quantity of pure gold to a workman to make a crown suspected that the artist kept part of the gold, and adulterated the crown with a baser metal. He applied to Archimedes to discover the fraud. The philosopher having long studied it in vain, accidentally hit upon a method of verifying the king's suspicion. Going one day into a bath, he took notice that the water rose in the bath, and immediately reflected, that any body of an equal bulk with himself, would have raised the water just as much; though a body of equal weight, but not of equal bulk, would not raise it so much. From this idea, he conceived a mode of finding out what he so much wished, and was so transported with joy, that he ran out of the bath, stark naked, crying, "I have found it, I have found it!

Since gold was the heaviest of all metals known to Archimedes, it occurred to him that it must be of less bulk, according to its weight, than any other metal. He, therefore, desired that a mass of pure gold, equally heavy with the crown when weighed in air, should be weighed against it in water, conjecturing that if the crown was not alloyed, it would counterpoise the mass of gold when they were both immersed in water, as well as it did when they were weighed in air. But upon making the trial, he found that the mass of gold weighed much heavier in water than the crown did; nor was this all; when the mass and crown were immersed separately in one vessel of water, the crown raised the water much higher than the mass did; which shewed it to be alloyed with some lighter metal that increased its bulk.

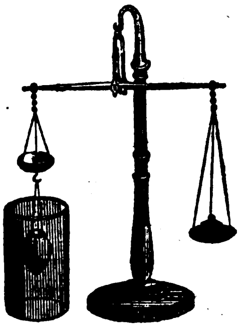
Experiment 7.

259. A body *immersed* in a fluid will sink to the bottom, if heavier than its bulk of the fluid. If it be *suspended* therein, it will lose as much of what it weighed in air, as its bulk of the fluid weighs. Hence, all bodies of equal bulks, which would sink in fluids, lose equal weights when suspended therein. And unequal bodies lose in proportion to their bulks.

The instrument used for ascertaining the specific gravities of bodies, is called the *hydrostatic balance*. and it differs little from a common balance when nicely made; only it has a hook at the bottom of one of the scales, on which substances to be examined may be hung by horse-hairs, or silk threads, so as to be immersed in a vessel of water, without wetting the scale.

If a body thus suspended under the scale, at one end of the balance, be first counterpoised in air by weights in the opposite scale, and then immersed in water, the equilibrium will be immediately destroyed; if, however, as much weight be put into the scale from which the body hangs, as will restore the equilibrium, without altering the weights in the opposite scale, that weight which restores the equilibrium, will be equal to the weight of a quantity of water as large as the immersed body; and if the weight of the body in air be divided by what it loses in water, the quotient will shew how much that body is heavier than its bulk of water.

Thus, if a guinea suspended in air, be counterbalanced by 129 grains in the opposite scale of the balance, and then, upon its being immersed in water, it becomes so much lighter as to require 7¼ grains put into the scale over it, to restore the equilibrium, it shews that a quantity of water of equal bulk with the guinea, weighs 7¼ grains, or 7,25; by which divide 129 (the weight of the guinea in air,) and the quotient will be 17,793; which shews that the guinea is 17,793 times as heavy as its bulk of water. And thus, any piece of gold may be tried, by weighing it first in air, and then in water; and if upon dividing the weight in air by the loss in water, the quotient comes out to be 17,793, the gold is good; if the quotient be 18, or between 18 and 19, the gold is very fine; but if it be less than 17, the gold is much alloyed with some other metal.



Experiment 9.

260. By this method, the specific gravities of all bodies that will sink in water, may be found; first weighing the body in air, then in water, and dividing the weight in air by the loss in water. But for those which are lighter than water, as most sorts

of wood are, take a pair of pincers or tongs, to retain the substance to be examined under water.

First weigh the body in air; then having balanced the tongs in water, fix to it the body to be weighed, which being lighter than water, will raise the tongs, and cause the other scale to preponderate. Observe the loss of weight of the body in water, and proceed as before. There are some things that cannot be weighed in this manner, such as quicksilver, fragments of diamonds, &c.; these must be put into a glass bucket, hanging to the scale. For finding the specific gravities of fluids, a solid glass bubble is used.

CHAPTER VIII.

MANUFACTURES.

SECTION I.

MANUFACTURE OF TIN PLATE.

261. This art was introduced into England from Bohemia, about the year 1670.

Bar iron of the finest quality, called tin-iron, made with the greatest care for this particular purpose, is first cut to the necessary length, and then rolled in a mill, into plates of the requisite thinness. These plates are then cut by hand-shears to the sizes suitable to the different markets. As the shearer shears the plates, he piles them in heaps, occasionally putting one plate the cross way, to keep each box separate:—Two hundred and twenty-five plates being called a box.

The iron plates now go into the hands of the scaler, who bends each of them singly across the middle, into this form (Λ) preparatory to their being cleaned for tinning, and for the conveniency of putting them into the scaling furnace.

This furnace, or oven, is heated by flame thrown into it from a fire-place of a peculiar construction; the plates are put into the oven in rows, and arranged three in each row, until the oven is full. It will be obvious, that if they lay flat on the floor of the oven, the flame could play only on one side of each plate; whereas, by being in a bent form, the flame can operate equally on both sides.

The operation of cleansing, which is preparatory to the process of scaling, is commenced by steeping the plates for the space of four or five minutes, in a mixture of muriatic acid and water, in the proportion of four pounds to three gallons. This quantity of the diluted acid will generally be sufficient for 1800 plates, or eight boxes of 225 plates each.

When the plates have been steeped for the time prescribed, they are taken out of the liquor, and placed upon the floor, three in a row, and then by means of an iron rod put under them, they are conveyed to a furnace heated red-hot, where they remain until the heat takes off the scale, the removal of which was the object in submitting them to that high temperature.

When this is effected, the plates are taken to a floor, where they are suffered to cool;—they are then straightened, and beaten smooth upon a cast-iron block. If the rust or oxyde which was attached to the iron, has been properly removed, they will appear mottled with blue and white, something like marbled paper.

They are now rolled a second time between a pair of cast-iron rollers, properly hardened and finely polished. This operation makes both sides of the plates perfectly smooth, and imparts a sort of polish to their surfaces. These rollers are each about 17 inches long, and 12 or 13 inches in diameter.

These rollers are used without heat, but they are screwed down very close one upon the other, only leaving bare room for the plates to pass, that the utmost attainable degree of pressure may be given to them.

The plates are now put one by one into troughs filled with a liquid preparation called the *lies*. This is merely water, in which bran has been steeped for nine or ten days, until it has acquired a sufficient acidity for the purpose. The design

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of putting the plates into the troughs *singly*, is, that there may be more certainty of the liquor getting between them, and both the sides of every plate being soaked alike in the lies. In this liquor they remain ten or twelve hours, standing on the edges; but they are turned, or inverted, once during that time.

The next operation is that of steeping in a mixture of sulphuric acid and water, in proportions which vary according to the judgment of the workmen.

The trough in which this operation is conducted, is made with thick lead; and the interior is divided by partitions of lead. Each of these divisions contain about one box of plates. In the diluted sulphuric acid which is in the different compartments of this vessel, the plates are agitated for about an hour, or until they have become perfectly bright, and entirely free from the black spots which are always upon them when they are first immersed in it.

Some nicety, however, is required in this operation, for if they remain too long in the acid, they will become stained. This and the former process with the acidulated water, are both hastened by giving to those menstrua an increase of temperature; and this is effected by means of heated flues which run underneath the trough.

When the plates come out of the pickle, they are put into pure water, and scoured in it, with hemp and sand, to remove any remaining oxyde, or rust of iron, that may be still attached to them, for wherever there is a particle of rust, or even dust upon them, there the tin will not fix. They are now put into fresh water to be there preserved for the process of tinning, for it has been found that they will acquire no rust, although they should be kept twelve months immersed in water.

All these processes are preparatory measures for the operation of tinning.

For this purpose an iron pot is nearly filled with a mixture of equal quantities of block and grain tin, in a melted state; and a quantity of tallow or grease sufficient, when melted, to cover the fluid metal to the thickness of four inches, is put into it.

When the tin-pot has been charged, the metal is heated from a fire-place underneath, and by flues which go round the pot, until it is as hot as it can be made without actually inflaming the grease which swims upon its surface. The use of the grease is to preserve the tin from the action of the atmosphere, and to prevent it from oxydating. By melting a little tin or lead in an iron ladle, and, when the dross is skimmed off, putting a morsel of tallow upon the metallic fluid; the effect of the tallow in cleansing the face of the metal will be evident. The workmen say, that it also increases the affinity of the iron for the tin, or, as they express it, that it makes the iron-plates take the tin better.

Another pot, which is fixed by the side of the tin-pot, is filled with grease only, and in this the prepared plates are immersed, one by one, before they are treated with the tin; and when the pot is filled with them, they are suffered to remain in it as long as is necessary. If they remain in the grease an hour, they are found to *tin* better than when a shorter time is allowed them.

From this pot they are removed, with the grease still adhering to them, into the pot which contains the body of melted tin; and in this they are placed in a vertical position. Three hundred and forty plates are usually put into this pot at once; and, for the sake of their being thoroughly tinned, they usually remain in it one hour and an half.

When the plates have laid a sufficient time immersed in the melted tin, they are taken out and placed upon an iron grating, that the superfluous netal may drain from them; but notwithstanding this precaution, when they become cold there is always more metal found adhering to them than is necessary; and this is taken off by a process called washing.

In the first place, the wash-man prepares an iron pot, which he nearly fills with the best grain-tin in a melted state; another pot of clean melted tallow or lard free from salt—a third pot with nothing within it but a grating to receive the plates—and a fourth, called the listing-pot, with a little melted tin in it, about enough to cover the bottom to the depth of a quarter of an inch.

The pots being all in a state of fitness, the wash-man commences by putting the plates which have undergone the various operations hitherto described, into the vessel of grain-tin called the wash-pot. The heat of this large body of melted metal, soon melts all the loose tin on the surface of these plates, and so deteriorates the quality of the whole mass, that it is usual, when 60 or 70 boxes have been washed in the grain tin, to take out 300 weight, and replenish the wash-pot with a fresh block of pure grain tin. These vessels generally hold three blocks each, or about half a ton weight of metal.

When the plates are taken out of the wash-pot, they are carefully brushed on each side with a brush of hemp of a peculiar kind, made expressly for the purpose.

The wash-man now takes a few plates out of the wash-pot, he then takes one plate up with a pair of tongs, which he holds in his left hand, and with a brush held in his right hand brushes one side of the plate—he then turns it, and brushes the other side, and immediately dips it once more into the hot fluid metal in the wash-pot, and without letting it out of the tongs, instantly withdraws it again, and plunges it into the grease pot.

Practice gives the workman so much expedition, that an expert wash-man, if he makes the best use of his time, will wash 25 boxes, consisting of 5,625 plates in twelve hours; notwithstanding, that every plate must be brushed on both sides, and dipped twice into the pot of melted tin.

The use of the grease pot is to take off any superfluous metal that may be upon the plates;—but this is an operation that requires great attention, because, as the plate is immersed in the grease while the tin is in a melting state upon it, a part must run off, and the remainder become less and less while the plate continues in it; therefore, if these plates should ever be left in the melted tallow longer than is absolutely necessary, they will doubtless require to be dipped a third time in the tin. On the other hand, if the plates were to be finished without passing through the grease, they would retain too much of the tin, which would be a loss to the manufacturer, and besides, the whole of the tin would appear to be in waves upon the iron.

The plates are now sorted, smoothed, and packed in boxes of 225 each, for sale; and of these are manufactured much of our kitchen utensils.

262. *Coke Ovens.*

At the Duke of Norfolk's colliery near Sheffield, several Coke Ovens are built on the side of a hill, occupying spaces formed within the bank. Each oven is circular, 10 feet in diameter in the inside, and the floor is laid with common brick set edgeways. The walls of the oven rise 19 inches above the floor, and the whole is covered by a brick arch which rises three feet five inches more, forming nearly a cone, whose base is 10 feet, and whose apex is two feet, if measured within. This opening of two feet at the top, is left for the convenience of supplying the oven with coal, and to serve as a chimney during the process. The whole height of the building from the floor is five feet, and the wall, which is 18 inches in thickness, is built with good brick, and closely laid, that no air may get in through any part of the work.

The floor is elevated three feet above the ground, for the convenience of placing a carriage under the door-way to receive the coke as it is raken from the oven. When the oven is thus finished, a strong perpendicular wall of common unhewn stone is thrown round it, of about 20 inches in thickness, and carried up the whole height of the oven, forming a complete square. The four corners between the circular building and these outward walls, are then filled with soil or rubbish, and well rammed to give greater firmness to the work, and the more effectually to exclude atmospheric air.

When these ovens are once heated, the work goes on night and day without interruption, and without any further expense of fuel. It is conducted thus:—Small refuse coal is thrown in at the circular opening on the top, sufficient to fill the oven up to the springing of the arch; it is then levelled with an iron rake, and the door-way built up with loose bricks. The heat which the oven acquires in the former operation is always sufficient of itself to light up the new charge: the combustion of which is accelerated by the atmospheric air that rushes in through the joints of the loose bricks in the door-way. In two or three hours the combustion gets to such a height, that they find it necessary to check the influx of atmospheric air: the door-way is therefore now plastered up with a mixture of wet soil and sand, except the *top* row of bricks, which is left unplastered all night. Next morning (when the charge has been in 24 hours) this is completely closed also; but the chimney remains open till the flame is gone, which is generally quite off in 12 hours more; a few loose stones are then laid on the top of the chimney, and closely covered up with a thick bed of sand or earth. All connexion with the atmosphere is now cut off, and in this situation the whole remains for 12 hours, to complete the operation. The door-way is then opened, and the coke is raked out into wheelbarrows, to be carted away. The whole takes up 48 hours; and as soon as the coke is removed, the ovens are again filled with coal for another burning. About two tons of coals are put in for each charge. These cokes are ponderous, extremely hard of a light gray colour, and shine with metallic lustre. They are used in those manufactures that require an intense heat. Gas making furnishes an ample supply of coke.

263. *Art of Crystallizing the Surface of Tin and other Metals.*

The process of giving the new ornamental surface on metals or metallic compositions, consists in employing those acids and saline compounds and substances which chemically act upon tin, and which, when employed in the manner to be stated, presently give to the metal or metallic compositions to which they are applied, the appearance of a crystalline surface variously modified; to produce this effect, the metal or metallic composition ought to be previously tinned or covered with a thin coat of tin. If the metal be pure tin, it requires no previous preparation. All grease remaining on the tinned surface, in consequence of tinning, is to be taken off with a solution of pot-ash, soap, or any alkaline substances.

The tin or tinned surface should then be washed with pure water, dried and heated to a temperature which the hand can bear; when the surface has thus been cleaned and heated, any of the acids which act upon tin, or the vapours of these, will cause the desired appearance of crystallization, but preference is given to the following composition, which may conveniently be laid over with a brush or a sponge: take one part by measure of sulphuric acid, dilute it with five parts of water. Take also one part of nitric acid, and dilute it with an equal bulk of water, and keep each of the mixtures separate; then take ten parts of the sulphuric acid, dilute it in the manner before stated, and mix it with one part of the diluted nitric acid, and then apply this mixed acid to the tin, or to the tinned surface, with a pencil or sponge, as above directed, and repeat the application of the said composition for several times successively, or until the result you expect proves satisfactory: when this has been done, the crystalline surface may be covered with a varnish or japan, more or less transparent and colourless, or coloured: the whole must now be polished.

264. *Manufacture of Copper.*

Copper is a red or orange-coloured metal, about nine times heavier than water. It is the most sonorous of all metals, and, except iron, the most elastic.

In a state of nature it is found under a great variety of forms, sometimes in masses of pure metal, but more frequently in combination with other substances. There are valuable copper mines in Great Britain, particularly in the island of Anglesea, and in Cornwall. This metal is likewise found in China, Japan, Africa, and in various parts of the continent of Europe.

It is employed for the covering of houses, sheathing the bottoms of ships, and for other purposes. As a covering for houses copper is lighter than slate, but whether it be more durable has not yet been ascertained. Plates, or flat pieces of copper, are used by artists for engraving pictures upon, either by cutting them with a sharp steel instrument or corroding them with aqua fortis, in lines drawn by a needle through a thin coat of wax spread upon their surface.

Copper is manufactured into various kinds of cooking utensils. Great care, however, ought to be taken that acid liquors, or even water intended for drinking, or to be mixed with food, be not suffered to stand long in such vessels, otherwise they will dissolve so much of the metal as to give them disagreeable and even poisonous qualities. Yet, it is remarkable that while acid liquors are kept boiling they do not seem to dissolve any of the metal. Hence it is that confectioners, by skilful management, prepare the most acid syrups in copper vessels, without their receiving any unpleasant taste or injurious quality from the metal. All vessels formed of this metal which are employed in cookery ought to have their inner surface covered with a thin coat of tin.

As copper does not, like iron, strike fire by collision, it has on this, as well as on some other accounts, been substituted for iron in the machinery which is employed in gunpowder mills.

265. *Making of Brass.*

Brass is a factitious metal, made of copper and zinc. By long calcination alone, and without the mixture of any other substance, brass affords a beautiful green or blue colour for glass; but if it be calcined with powdered sulphur, it will give a red, yellow, or chalcedony colour, according to the quantity and other variations in using it. Brass is of a yellow colour, more fusible than copper, and not so apt to tarnish.

Pure brass is not malleable unless *hot;* when cold it will break; and will not bear the hammer when it has been twice melted. To render it soft and pliable, and capable of being wrought, seven pounds of lead are added to a hundred weight of brass. It is peculiarly adapted for wire, being capable of great extension, and is much used in watch-work. *Corinthian brass,* so famous in antiquity, was a mixture of gold, silver, and copper. *Brass colour* is a preparation intended to imitate brass; of which there are two sorts, the *red* brass or bronze, and the *yellow* or gilt brass: the last is made only of copper filings; with the former, red ochre, finely pulverized, is mixed, but both are used with varnish *.

266. *Manufacture of Lead and Pewter.*

Lead is a heavy metal, of pale and livid grey colour when broken, not sonorous when pure, very flexible, and so soft that it may be marked with the nail. It is easily reduced into thin plates by the hammer; it stains paper or the fingers of a bluish colour, and is about eleven times heavier than water.

The most common state in which lead is found is in combination with sulphur and a small portion of silver. This ore is known by the name of *galena*, and is frequently in the form of blackish cubical crystals. Lead is also found in union with arsenic and many acids.

There are lead mines in several parts of Great Britain; but perhaps those of Flintshire and Derbyshire are more celebrated than any others.

When first melted it is bright, but it soon tarnishes by exposure to the air. It melts at a temperature very low in comparison with most other metals; and when a strong heat is applied, it boils and evaporates.

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* The appearance of brass is given to other metals, by washing them with a yellow lacquer or varnish, much to the detriment of the manufactured article.

When rolled between iron cylinders to a requisite thinness and uniformity, it is used for the covering of houses and churches. It is cast into pipes, cisterns, reservoirs for water, and large boilers for chemical purposes. But all culinary or domestic vessels made of lead, particularly if intended for the keeping of acid liquors, should carefully be avoided, since the surface of the lead is thereby corroded, and the liquid contained in them is rendered poisonous. Hence arises that dreadful complaint too well known where cyder is kept in leaden cisterns, called the *Devonshire colic*: hence also the injury which sometimes arises from the use of lead in the glazing of coarse earthenware.

267. *Pewter.* An alloy of lead and tin in the proportion of two parts of lead and one of tin, forms the *solder* which is used by plumbers; and, in the proportion of one part of lead to three parts of tin, it constitutes what is called *ley pewter*. The *types* which are used by printers for very large characters, are sometimes composed of an alloy of lead and copper.

268. *White Lead.* Is made by suspending thin plates of lead over heated vinegar, in such manner that the vapour which rises from the acid may circulate about the plates; which, by this process, become at length entirely corroded, and converted into a heavy white powder.

The manufacture of white lead is a trade confined to a few persons, who have large conveniencies for the purpose. This substance, when mixed with oil, is used as a paint for wood-work both of the outsides and insides of buildings.

269. *Red Lead* is used both as an external medicine and a pigment. In the former case it abates inflammations, cleanses and heals ulcers; but then a skilful surgical hand must use it.

270. *Sugar of Lead* is a preparation from white lead and distilled vinegar. It is usual to find it in the form of small slender crystals, with a glossy appearance like satin. It is employed by dyers and calico printers; and is the basis of the liquid called *Goulard*, or *Goulard's Extract*. Although in itself a virulent poison, it is often used by oil-men, and

for correcting the rancidity of oil of almonds and olive oil; and a similar pernicious fraud is practised by wine merchants by dissolving a portion of it in wines that are becoming acid, in order to correct their acidity.

These frauds are easily detected by preparations or tests, sold by chemists. The best and simplest test is Harrowgate water; a little of this poured into the suspected compound discovers the presence of lead by giving to the fluid a *dark brown* tinge.

The following pleasing experiment may be performed with sugar of lead. Dissolve an ounce of sugar of lead in a quart of water; filter the solution through a piece of blotting paper, and put it into a glass decanter, suspending in it a piece of zinc by a brass wire. A decomposition takes place; the lead is set at liberty, and attaches itself to the zinc, forming a sort of metallic tree.

271. *Manufacture of Iron and Steel.*

Iron is a well known metal, of a livid greyish colour, hard and elastic, and capable of receiving a high polish. Its weight is nearly eight times as great as that of water. It is seldom found in a native state, but occurs abundantly in almost every country of the world in a state of oxyde, and mineralized with sulphuric, carbonic, and other acids. It is found in plants, in several kinds of coloured stones, and even in the blood of animals.

After iron ore has been dug out of the earth it is broken into small pieces, by machinery, then washed, to detach the grosser particles of earth which adhere to it. Then thrown into a furnace mixed with a certain portion of lime-stone and charcoal, for the purpose of being melted. Near the bottom of each furnace there is a tap-hole, through which the liquid metal is discharged into furrows made in a bed of sand. The larger mass, or that which flows into the main furrow, is called a *sow*; the smaller ones are denominated *pigs* of iron; and the general name of the metal in this state is *cast-iron.*

272. *Cast iron* is distinguishable by its properties of being, in general, so hard as to resist both the hammer and the file being extremely brittle, and

for the most part, of a dark grey or blackish colour.

A great number of useful and important articles are formed of cast iron, such as stoves, grates, chimney-backs, pots, boilers, pipes, and cannon shot. These are made by casting ladles full of the rough metal into moulds shaped for the purpose in sifted sand.

273. *Wrought iron.* The process of converting cast iron into wrought or malleable iron, is called *blooming.* The cast iron is put into a furnace, and melted by the flame of combustibles which is made to play upon its surface, a workman constantly stirring it, until, notwithstanding the continuance of the heat, it gradually acquires consistency and congeals. It is then taken out, while hot, and violently beaten with a large hammer worked by machinery. In this state it is formed into bars for sale.

By means of this metal the earth has been cultivated. Without it, houses, cities, and ships could not have been built; and few arts could have been practised. It forms also the machinery by which the most useful and important mechanical powers are generated and applied.

274. *Steel* is usually made by a process called *cementation.* This process consists in keeping bars of iron in contact with powdered charcoal during a state of ignition for several hours in earthen troughs, or crucibles, the mouths of which are closed up with clay.

Steel, if heated to redness and suffered to cool slowly, becomes soft; but if it be plunged whilst hot into cold water, it acquires extreme hardness. And, by heating steel to different degrees, it receives different degrees of temper, from that which renders it proper for files, to that which fits it for the manufacture of watch springs.

All kinds of edge tools where excellence is required, are made of steel; and a steel instrument may be known from an iron one, by letting fall upon it a drop of aqua fortis: if it be steel this will occasion a black spot, but if it be iron, it will not have this effect.

Iron, exposed to the moisture of the atmosphere, becomes covered with a brown substance called *rust*, which if suffered to continue without interruption will corrode the whole mass; but this rust or *oxyde* is used by calico-printers for a dye.

If linen be exposed to iron in damp situations, it will receive spots called *iron-moulds*, which can only be removed by the application of an acid.

275. *Manufacture and Uses of Animal Charcoal. Ivory Black.*

The physical and chemical properties of animal charcoal have been known only for a few years. Formerly bones and ivory were calcined in close vessels merely to procure a fine black for painting; but since the discovery of the properties of charcoal as a purifier and clarifier, it is used in sugar-refineries, laboratories, and distilleries, as well as for purifying oil, &c.

There are many manufacturers of animal charcoal in Paris. Their process is very simple. Some, after filling a number of earthen or iron pots with broken bones, lute on the cover with potters' earth, then pile one over the other in a potters' kiln, which is heated with wood or pit-coal: when the degree of heat becomes sufficient to decompose the gelatine and oil of the bones, the luting cracks in small fissures, and gives issue to the carbonized hydrogen gas, which escapes from the furnace by several small apertures made for the purpose, one above another, and on reaching the atmospheric air becomes ignited, and is consumed. When this flame goes out, the combustion is completed. In England and France, other manufacturers distil bones in cylinders of cast-iron that run through a great fire-place, or in iron alembics; but in these manufactories the bone-black is looked upon as of only secondary importance; for it is for the purpose of making carbonate, sulphate, and muriate of ammonia, that they generally distil bones. Without that, the black would come too dear.

Every kind of bone does not yield a similar kind of coal; this coal varies in quality, according as we employ old or young animals' bones, round or flat, heavy and compact, or spongy and light ones. It was natural to think that young animals' bones contained more gelatine than those of old, and consequently ought to yield a deeper black and more charcoal. This was an error; for great round bones, such as the femur and tibia of an ox, yield more coal, when distilled, than similar bones of equal weight taken from calves. The proportion of black-charcoal in young animals' bones is only four or five per cent., while that of old compact bone amounts to 40.

Animal charcoal is a mixture of phosphate of lime, a small quantity of quick-lime, and charcoal. The property of clarifying liquids depends on the mixture of these substances, none of which separately possess this property so perfectly. When bones do not appear to contain much gelatine, the manufacturers take care to add, in the furnace, soft animal matter, such as clotted-blood, tripe or guts, membranes, &c. This is the reason why many refiners esteem most the black produced by the calcination of blood and potash, in Prussian-blue manufactories.

Whether animal charcoal is intended for painting or clarifying, that which contains the greater proportion of carbon is to be preferred; and this proportion is always easily discovered, by the application of muriatic acid to the coal. This acid dissolves the calcareous salts and the lime. The coal is then dried and weighed:—should it equal forty-hundredths of the analysed coal, it is very fit for painting and clarifying; but the painters require it much finer than the refiners.

Many refiners, who make use of animal black, have wisely judged that it might serve more than once. So that when it has lost its effect as a filtering clarifier, they wash it well in a great quantity of water, and calcine it again with or without the addition of animal matter. They have remarked, that this coal, twice or thrice calcined, was more advantageous, and clarified syrups better, than that which had been calcined only once. The manufacturers of bone-black are, consequently, interested in buying up the coal from the refiners (after they have made use of it), to calcine it over again.

Some manufacturers grind the bone-black dry, while others make use of water; and this latter method is both more expeditious and wholsomer for the workman; after that it is dried before being offered for sale.

In sugar-houses bone-black is sometimes employed as a simple filter; and in this case they only pour the syrup on the moistened animal coal: but when required as a clarifier, it must be boiled up with the sugar, in the proportion of one-tenth to the quantity of sugar to be clarified. Before the sugar, dissolved in a sufficient quantity of water, has been boiled, and brought to the consistence of syrup, the coal is poured, little by little, into the boiler. After seven or eight minutes' longer boiling on the fire, all is thrown together into a woollen bag disposed for that purpose. The syrup at first passes a little coloured by the coal it carries along with it; but then they pour it back into the bag, and it runs out clear.

Syrups worked with coal yield a much more abundant crystallization, and are of a very superior quality, to syrups worked without it.

It is to M. Lowitz we owe the discovery of the property of powdered charcoal for clarifying animal and vegetable substances, at the same time that it takes away their smell. In 1791 he clarified gum-arabic, gelatine, beer, milk, red wine, vinegar, tincture of cochineal, &c.; but the greater part of these substances had been decomposed. He attenuated the smell of bitumen, flowers of benzoin, bugs, empyreumatic oils, the infusion of valerian, &c. by the sole use of wood coal.

In 1810, M. Figuier, professor of chemistry in Montpellier, after repeating M. Lowitz's experiments, tried animal charcoal, and found it possessed a stronger power of clarification than vegetable coal. Since this period, both are employed to keep water fresh at sea, and to purify oil and water, meat and fish, in the first stage of putrefaction. It is used, moreover, to render the most corrupt water potable, to clarify honey, syrups, &c.

276. *Cure and Prevention of the Dry-rot in Timber.*

The following excellent method of effecting this desirable purpose is put in practice and recommended by Mr. Randall of Fitzroy-Square, London.

My method of curing the fungus of dry rot, consists, as a preliminary, in carefully examining the place in which it is, and the cause of it, to ascertain whether it has arisen from a natural defect in the situation of the house, or from a stimulus which may have been given to the wooden-work by accident. In the former case a more comprehensive plan will be required in effecting a cure than may be, perhaps, found necessary for the latter. When these circumstances have been duly considered, my next operation consists in removing the decayed wood, and selecting out such only as may not be found too much so to be repaired, and again replaced. After which I proceed in the preparation. The timbers of a building, such, for instance, as the joists, plates, girders, &c. may be charred or oxydated by the common operation of burning their surfaces; to facilitate which, washing them slightly with nitre in solution, will be found very much to promote: straw, or shavings of deal wood, will answer the purpose, and it is only necessary in doing them to equally diffuse the fire, so that the timber be charred all over its surface in an equal degree. Care must also be taken that the smaller kinds of timber be not too much burned by the fire, so as to destroy their required strength, which may be the case, by doing it with too little attention. This may be completely prevented by the slightest care, and particularly if the wood has been previously covered with a solution of nitre, as in this case the fire will, on its first impulse, run over the whole surface, and leave it sufficiently burned for the purpose. When the charring is completed, the surface should be brushed, to free it of the dust and soot which it has collected in burning; after which it is in a state to receive the painting. The composition for this paint, if it may be so called, is prepared as follows, viz.—to four pounds of sulphate of iron is added two gallons of boiling water, stirring the crystals of iron with a spatula, till they are completely dissolved in the water. After which I put it in bottles, well corked up, and in a day or two it will be in a state for use. The painting is best done by a large flat hog's-hair brush, pouring out a small quantity of the solution at a time into some portable machine, and brushing it over the charred surface of the wood. Once covering is sufficient, and the only care required is in well and completely spreading it all over the surfaces. The expence is by no means considerable, as it is ascertained that two gallons of the solution will paint upwards of 250 feet superficial of surface, and the expence of four pounds of sulphate of iron is one shilling and fourpence only; and a man, at all dexterous with the brush, may cover the above quantity in two hours; and hence the expence will not amount to more than a fraction per foot superficial. When large quantities of wood are intended to be painted with the solution, it may be desirable to prepare it in adequate quantities; this may be done by apportioning the ingredients accordingly.

277. Glass Making.

Accident is said to have discovered the constituent parts of glass. Some merchants, with a freight of soda, cast anchor at the mouth of the river Belus, in Phenicia, and were dressing their dinner on the sand, using large lumps of the soda as supports for their kettles. The fire melting the soda, and the siliceous earth together; exhibited *glass*. A manufacture was instantly established, and to this place it was for a long time confined.

Glass was made in great perfection among the ancients; as drinking glasses, prisms, and coloured glasses of various kinds. It was known to the Romans, but was by no means common among them, for Nero paid £50,000 for two glass cups. Glass was first used for windows in the third century.

Glass is a solid, transparent, brittle substance, produced by melting together sand, flint, and alkaline salts. There are other saline matters employed in the manufactory of glass, as *poeverine* or *rochetta*, which is prepared from glass wort or *salsola kali*, an indigenous plant, but which is chiefly imported from Spain, where it is cut down in the summer, dried in the sun, and burned in heaps, when the ashes fall into a pit, where they concrete into a hard mass. A similar salt is obtained from the ashes (*kelp*) of the common sea-wrack. The sand used in the manufacture of glass is found at Lynn in Norfolk, and Maidstone in Kent.

The following are the processes employed in making glass.

1. *Fritting*. The various materials are carefully washed, and after extracting all the impurities, are conveyed to the furnace in pots made of tobacco-pipe clay. The produce of this process is called the *frit*, which is again melted in large pots or crucibles, till the whole mass becomes beautifully clear, and the dross rises to the top

2. *Blowing* is the next process, which in round glass, as phials, drinking-glasses, &c. is thus performed.

The workmen dip the end of long iron pipes, red hot, into the liquid glass, then roll it on a polished iron plate to give it an external even surface; they next blow down the iron pipe till it enlarges the metal, like a bladder, and, if necessary, roll it again on the iron plate, and proceed to form it into a globular, or any other shape required. The glass is then transferred from the blowing pipe, by dipping the end of another iron rod into the liquid glass, which adheres to the heated rod, and with which the workman sticks it to the bottom of the vessel: then with a pair of pincers, wetted with water, he touches the neck, which immediately cracks, and on being slightly struck separates at the end of the blowing pipe, and becomes attached to the iron rod. The vessel is next carried up to the mouth of the furnace to be heated and softened, that the operator may finish it. If the vessel require a handle, the operator forms it separately, and unites it while melting-hot, forming it with pincers to the requisite shape and pattern.

3. *Annealing* is the removing of the glass after it has been blown, or cast, into a furnace, whose heat is not sufficiently intense to melt it; and gradually withdrawing the article from the hottest to a cooler part of the annealing chamber, till it is cold enough to be taken out for use.

4. *Colouring.* The different coloured glasses owe their tints to the different metallic oxydes, mixed with the materials, while in a state of fusion.

Blue glass is formed by the oxyde of cobalt;
Green by the oxyde of iron or copper;
Violet by the oxyde of manganese;
Red by a mixture of the oxydes of copper and iron;
Purple by the oxyde of gold;
White by the oxyde of arsenic and zinc;
Yellow by the oxyde of silver and by combustible bodies,
And *Black* from a mixture of oxyde of manganese, cobalt, and iron.

In this manner is made those elegant *pastes*, which so faithfully imitate, and not unfrequently excel, in brilliance, their originals, the gems of antiquity. The glass, however, for this purpose, is prepared in a peculiar manner, and requires great nicety. It combines purity and durability. *Opaque* glass is made by the addition of the oxyde of tin and produces that beautiful imitation of enamel which is so much admired. Dials for watches and clocks are made in this manner, and are manufactured exclusively at the Falcon Glass-House, Surry side of Blackfriars bridge.

5. *Cutting or ornamenting* is effected by a machine, in which there is a large wheel turned by a winch. The band of this wheel passes round a pulley on the axle of a wheel or cutter, which it turns with great velocity.

Beneath the cutter a cistern is placed, and above it a small cask containing water, the cock of which is so placed as to drop very slowly on the circumference of the cutter. The operator, after dressing the edge of the cutter with emery paste, applies successively the parts of the glass which are to be cut, and dexterously moves it as the parts are sufficiently ground away.

278. The principal sorts of glass are, 1. *Crown glass.* The best window-glass is made of white sand, purified barilla, salt-petre, borax, and arsenic, melted together; and if the glass assume a yellowish hue, the defect is removed by adding a sufficient quantity of manganese.

279. *Newcastle glass,* generally used in England, is of an ash colour, frequently speckled, streaked, and blemished. It is made from white sand unpurified barilla, common salt, arsenic, and manganese.

280. The *bottle* or *green* glass, usually made of common sand, lime, and some clay fused with an impure alkali, is very hard, and resists the corrosive action of all liquids much better than flint glass:—the green colour is owing to the iron:—it is well adapted for chemical vessels.

281. *Flint glass,* the most fusible of any, is used for bottles, utensils intended to be cut and polished, and for various ornamental purposes. The best kind is composed of white siliceous sand, pearl-ash, red oxyde of lead, nitrate of potash, and the black oxyde of manganese.

282. *Plate glass,* so called from its being cast in plates or large sheets, is the most valuable, and is employed for mirrors and the windows of carriages. It is composed of white sand cleansed with purified

pearl ashes and borax. But should the metal appear yellow, it is restored to its pellucid transparency by the addition (in equal proportions) of a small quantity of manganese and arsenic. It is cast on a large horizontal table, and all excrescencies pressed out by passing a large roller over the metal. To polish the glass it is laid on a large horizontal table of freestone perfectly smooth: and then a smaller piece of glass fastened to a plank of wood, is passed over the other till it has received its due degree of polish. But to facilitate this process, water and sand are used as in the polishing of marble; and lastly, Tripoli stone, smalt, and emery, to give it lustre.

SECTION II.

MANUFACTURE OF POTTERY.

283. POTTERY is the art of making vessels from earth, and it is of the remotest antiquity. In the earlier ages of the world, almost all domestic utensils, were of pottery, which may hence be fairly supposed the oldest of mechanical inventions. The Scriptures first mention the practice of this art. The numerous remains of Greek and Etruscan vases prove that these nations were celebrated for their skill in pottery. The Greek vases in Sir William Hamilton's collection, deposited in the British Museum, are ornamented with truly elegant paintings, and their forms are equally simple and beautiful.

284. Porcelain (from the Portuguese word, porcelena, a cup) the most perfect species of earthenware, is distinguished from the inferior kinds of pottery which are opaque, and of various colours, by its being white and semi-transparent. Europe has been excelled by oriental nations, in the art of making

porcelain, for the first seen in Europe was brought from Japan and China.

The Chinese porcelain is composed of two ingredients; 1. pe-tunt-se, a hard stone which is carefully ground to a powder; and 2, ka-o-lin, a white earthy substance, which is intimately mixed with the ground stone. These two materials, however, are considered the same; the former only being worked into a clay with water after it is ground.

The whiteness, transparency, and elegance of this pottery, did not fail to excite the admiration and industry of Europeans. The first produce of this excellent spirit of emulation appeared in Saxony, then in France, and afterwards in England, Germany, and Italy; but all these were different from the Japanese, and each had a peculiar character of its own. Besides the manufactory of Saxony, which has been long established, porcelain is made at Vienna, at Frankendal, and lately in the neighbourhood of Berlin. In France, the Serres porcelain holds the most distinguished rank. Italy also has its porcelains, the best of which are those of Naples and Florence.

285. The potteries of England have made rapid advances towards perfection. The chief establishments are in Staffordshire, at Derby, Worcester, and Coalport, in Shropshire.

The Staffordshire potteries have long been celebrated for their earthenwares, and some of the principal proprietors have directed their attention to the manufacture of porcelain, which has attained a high degree of excellence. The earthenwares formerly manufactured here were coarse, the finest sort was an imperfectly white ware, very slightly ornamented with blue, and glazed by throwing into the oven while the ware was firing, a quantity of common salt; the salt was converted into vapours, and applied to the surface of the vessels, formed the glazing. The colour of the body of this kind of ware is said to have received considerable improvement from the following incident:

Mr. Astbury, a Staffordshire potter, travelling to London, perceiving something amiss with one of his horses' eyes, a hostler at Dunstable offered to cure the animal, and for that purpose put a common black flint stone into the fire. When taken out, it was observed to be of a fine white; the potter immediately conceived the idea of improving his ware, by adding this material to the whitest clay he could obtain. He sent home a quantity of the flint stones, and by mixing them with tobacco-pipe clay produced a white stone ware superior to any that had been made before. The other potters followed his example.

286. In the year 1763, Wedgwood invented a species of earthenware for the table, quite new in its appearance, and covered with a rich and brilliant glaze. To this new manufacture her late Majesty gave her patronage, commanding it to be called Queen's Ware, and honouring the inventor by appointing him her Majesty's potter. Hence may be dated a new æra in this interesting and important manufacture. Wedgwood's ware evinces considerable taste in the elegance of his antique models, and in the excellence of their execution.

287. SPODE'S WARE. But great improvements have been made in the art of pottery since Wedgwood's time. Blue-printed (or blue and white) ware, in imitation of the oriental china, or porcelain, has been introduced with great success in various manufactories, but particularly in that of Josiah Spode, at Stoke upon Trent, in Staffordshire.

The potteries in this county are not less than one hundred in number; employing more than ten thousand persons; and the annual value of goods manufactured there, may be estimated, in the most flourishing times, at eight hundred thousand pounds sterling.

A canal furnishes the manufacturers with the means of water-carriage to every principal sea-port in the kingdom; greatly facilitating the exportation of the manufactured article, and the importation of the raw material.

The number of persons employed in Mr. Spode's establishment amounts to more than seven hundred, and the latest discoveries in machinery are applied to the advancement of the art. We shall now proceed to describe the general processes pursued at Mr. Spode's manufactory, and which may be classed thus: preparations of the raw material, moulding and turning, firing, printing, glazing, and painting.

288. *Preparation of the raw material.* A powerful steam-engine performs many of the processes hitherto carried on by manual labour. The bodies of

earthenware are composed of Kent flint and West of England clay.

The flint is calcined in kilns, similar to those in which lime is burnt; it is then broken into small pieces, by revolving hammers, put in motion by the steam-engine; these pieces are then conveyed into the pans, to be ground with water added. The pans are paved with stone, in the centre there is an upright shaft, from which several transverse arms branch out, having very heavy stones placed between them; these stones are moved horizontally, by the steam-engine, and grind the flints, until they form with the water a cream-like liquid. This is let off into the wash-tub, where the coarser particles are here separated from the fine, the latter runs off into reservoirs, and the former is carried back to the grinding pan. When the ground-flint is wanted for use, it is conveyed from the reservoir by a pump worked also by the steam-engine.

The process of preparing the clay, and mixing it with the flint is this.—The clay is drawn up into the upper chamber of the slip-house, and there thrown into an iron box, in which moves a shaft, with knives fixed in it, to cut the lumps into small pieces.

The clay is now laid in a cistern with a proper quantity of water, where it softens, and is then put into the plunging-tub; in this tub the water and clay are stirred until they become thoroughly mixed. The liquid is now drawn off into another cistern, from which it passes through a silk sieve into a third cistern, then into a fourth, through silk sieves still finer, the ground flint and other ingredients are now brought and mixed together; and the whole passes through sieves of a greater degree of finenesses, into a fifth cistern: in this is a pump that throws it into a trough for conveying it to the drying kiln.

These various operations are worked by the steam-engine, and there are fourteen sieves in motion at one time. After the clay has been dried, it is taken from the kiln and laid together in large heaps, and before it is worked into the vessels for which it is destined, the air-bubbles are disengaged from it.

This is done by a machine turned by the steam-engine; the machine is an iron box shaped like an inverted cone, with an upright shaft in its centre, to which are affixed knives to cut the clay which is put into the box, by their rotatory motion; and, at the same time, so arranged, as to force it downwards to a square aperture at the bottom, it escapes through this in a sufficiently compressed state for the workmen, and is then cut into square pieces of a convenient size to be distributed in the manufactory. Near the steam-engine are work-shops for those branches of the trade which require the aid of machinery; and in this building, there are eight throwing wheels, and twenty-five turning lathes. Underneath these shops are drying-houses, heated by steam, in which the ware is dried, previously to its going to the oven to be fired; above the work-shops is a single room capable of holding two hundred workmen.

289. *Moulding and Turning.* Tea-cups, saucers, basons, jugs, and such like vessels, receive their first shape from the hands of the thrower. He sits on a stool with a flat circular wooden wheel before him, moving horizontally on a pivot.

This wheel is set in motion by the steam-engine, and he can increase or diminish its velocity as there is occasion. Upon the centre of the wheel the operator throws a lump of clay, of the required size, and forms it into almost any shape with the utmost facility: it is then cut from the wheel by a wire, and taken to be dried that it may acquire sufficient hardness to fit it for the next operation.

By turning, the superfluous parts of the clay are taken off, so as to render the article perfectly smooth, and to give it the exact shape. The lathes on which the vessels are turned, are put in motion by the steam-engine, and regulated as to speed by the turner himself. The principle of turning earthenware is very similar to that employed in wood-turning.

The vessels requiring handles and spouts, are taken to the handling room, and those which do not want this appendage, after having attained the requisite hardness, are sent to the oven to be baked.

The handles are made on a mould of plaster of Paris, and fixed to the vessel with a liquid mixture of the same material as the vessel itself.

For the formation of various articles manufactured in all potteries, moulds made of plaster of Paris are necessary. The modeller forms the shape of the intended vessel out of a solid lump of clay, which after receiving his finishing touches, is handed to the person who makes the plaster mould from it.

Plates and dishes are made from moulds of this kind, upon which the operator lays a piece of clay of the length, breadth, and thickness required; the mould and clay are then placed upon a wheel turning horizontally on a pivot, and the operator keeps peeling round with the left hand, and presses the clay to the shape of the mould with the other. The mould and dish together are then carried into a stove moderately heated, where it remains until sufficiently dried to separate. The plate or dish is then cut even at the edges, and in other respepts finished: before they are baked the dishes are laid flat upon plaster or stone flags that are quite level, in order that they may remain straight until they go to the oven to be fired.

Tureens, vegetable dishes, and such articles are also made in moulds, but require more time and care, being less simple in their form.

Figures, flowers, and foliage in bas-relief, are also formed separately in moulds, and afterwards affixed to the vessel with diluted clay.

290. *Firing.* When the ware is ready for firing, it is placed in clay cases called saggars, which vary in size and shape according to the articles placed in them. The saggars are put into an oven, shaped like a bee-hive, with an opening at the top; there is also an opening at the side to admit the saggars, but this is closed before the fire is applied.

Each saggar is luted to the other by a roll of soft fire-clay. This secures the vessels contained in them from dust, the fumes of the fires, and from the effects of the air when the oven is cooling. The fires which heat the oven are placed round it in proper receptacles, which communicate with the interior of the oven, by flues, heating every part equally. This first firing gives a higher degree of heat, and is continued much longer than any successive firing; when once fired, the article is called biscuit-ware.

The cream-coloured, or queen's-ware, is now carried to the dipping-house to receiving its glazing; that which is to be printed blue is taken to the printing-house.

291. *Printing.* The design is previously engraven on a copper-glate, and laid on a stone to warm. The colour (which has oxyde of cobalt for its basis) is mixed with a preparation of oils, to fetch out the impression. This mixture is smeared over the surface

of the plate, and again cleaned off, leaving the liquid in the engraving only.

The paper used to take off the impression is made expressly for this purpose; it is damped, laid on the copper-plate, and passed between two iron-rollers, as in ordinary copper-plate printing. The design being transferred to the paper, is laid immediately upon the ware, being rubbed on with a flannel. After remaining a short time the ware is put into a tub of water, and the paper is separated from it with a sponge, leaving the design in the most perfect state. The ware is then dried, and taken to the oven to be burned; during this operation, the oil which has been mixed with the colour in the printing is destroyed, and the oxyde of cobalt more firmly attached to the ware: it is then glazed.

292. *Glazing*. The glazers differ in their composition in all manufactories, most however have oxyde of lead for their basis. The ingredients being mixed with water, and well ground, the glaze is ready for use, in which the vessels are dipped. On drying, which takes place instantly, the water contained in the glaze being absorbed by the porosity of the vessel, it is covered with a fine white powder of a regular thickness, this, when fired, becomes vitreous, or assumes a glass-like appearance, and from its transparency, the blue pattern underneath is rendered perfectly visible.

In the last firing, especial care is taken to keep one piece from touching the other, or the whole would fuse into one united mass. Great attention is also requisite in the firing, not to give too much or too little heat, either extreme being injurious; the fireman in this, as in the other firing, draws out trial pieces from the oven, with an iron rod, to ascertain the proper degree of heat.

293. *Painting*. The pieces of porcelain or earthenware to be enamelled and enriched by gilding are, after the first firing, dipped in a suitable glaze, and again submitted to the fire. They are then delivered to the painter or enameller. The colours used in enamel-painting are composed of metallic calxes, and fluxes suitable to each colour, separately and conjointly, and of such a nature as to fuse them suffici-

ently for the glazing on which they are laid. Gold has also its flux, and is laid on as the other colours are.

When the painting is completed, the ware is placed in a furnace less in size, and different in construction from that before noticed. Care is here necessary in the arrangement of the vessels, and great nicety is required in the degree and the continuation of the heat, which is not so intense as in the former firings. The colours, after this firing, put on a shining appearance, but the gold has an opaque yellow cast, and is burnished with a blood stone to give it the desired brilliancy.

Obs. The processes already detailed for the manufacture of earthenware, are applicable, in nearly every case, to that of porcelain. The composition of the bodies and glazes is, of course, different; and much greater care is necessary in every process, than is bestowed upon earthenware in general.

294. *Delft Ware,* so called because first made at Delft, in Holland, is a kind of pottery of baked earth, covered with a white glazing, which gives it the appearance of porcelain.

The basis of this pottery is clay mixed with a certain quantity of sand; the vessels are slightly baked, so that they resist a sudden application of heat; and they are, lastly, covered with an enamel or glaze, which is composed of common salt, sand ground fine, and the oxydes of lead and tin. The latter gives a white opaque colour to the mass. The furnace and colours used for painting this ware, are the same as those which have been noticed as employed for porcelain.

CHAPTER IX.

THE MANUFACTURE OF CLOTHS, &c.

SECTION I.

WOOLLEN CLOTHS.

295. The Woollen Manufacture includes the several commodities into which wool is wrought, among broad cloths, kerseymeres, baize, serges, flannel, says, stuffs, frize, stockings, caps, rugs, &c. Cloths are woven in a loom, as well as linens, druggets, serges, camblets, &c.

The word cloth is applied to a web, or tissue of woollen threads, interwoven; of which some, called the warp, are extended logitudinally, or from one end of the piece to the other; the rest, called the woof, are disposed across the first, or the breadthway of the piece. The goodness of cloth depends on many circumstances. It should be well wrought on the loom, to be every where equally close and compact. The wool must not be finer and better at one end than another. The list should be sufficiently strong, and of the same length as the stuff. For coarse cloth, they should consist of coarse wool and cow hairs from Scotland; for fine cloth, of Vigonia, or Alpaca wool (taken from the lama,) from South America. The cloth must be cleared of knots and other imperfections; scoured with fuller's earth, then fulled with white soap, and washed in water. The hair, or nap, must be well rowed, or drawn out with the teazle, and shorn close, without laying the thread bare; it must be well dyed, and not stretched, further than is necessary to bring it to the just length and breadth; and finally, it must be properly pressed.

296. In Gloucestershire, the different processes in the manufacture of cloth, are these:

1. *Scouring*. When the wool has been taken out of the packs, it is scoured in a liquor composed of three parts of water and one of urine, to which soap is added; it is then drained, washed in a running stream, and dried.

2. *Beating and Picking*. It is beaten with rods on hurdles of wood, or on ropes, to clear it of the dust and filth. After beating it is well picked, to clear the filth that has escaped the rods.

3. *Oiling and Scribbling*. When the cloth has been oiled with the oil of olives, which is the best for this purpose, it is carried to the scribbling-mill. This mill consists of a system of cylinders coated with coarse cards, on the surface of which the wool being regularly transferred, comes out in one uniform layer.

4. *Carding and Spinning*. It is now brought to the carding machine, which is like the scribbling machine, but composed of finer cards, to the last cylinder of cards a fluted wooden cylinder is adapted, to scrape off the wool in thin rolls. The wool is spun for woof by a machine called a Jack, consisting of from sixty to eighty spindles, worked by one person; the warp is slooped, or spun by a machine called a Billy, containing from sixty to eighty spindles worked by one person, and afterwards drawn finer by another machine termed a Jenny, containing from eighty to an hundred spindles, also worked by one person; the yarn is then reeled for the weaver.

5. *Sizing.* When warped, it is stiffened with size, made of shreds of parchment; and when dry, it is given to the weaver, who mounts it on his loom.

6. *Weaving* is performed by a new-invented spring loom, worked by one person. The spring throws the shuttle backwards and forwards, and the weaver strikes the frame, in which is fastened the comb or reed, between whose teeth the threads of the warp are passed, repeating the stroke as often as is necessary; cloths in general only require two or three strokes, but some require more. The weaver having continued his work till the whole warp is filled with woof, the cloth is finished; when it is taken off the loom, by unrolling it from the beam.

7. *Sigging.* When the cloth is taken out of the loom it is sigged, or washed in the stock, a solution of pig's dung, urine, and water.

8. *Burling.* The cloth is now dried and burled; that is, the straw, knots, threads, and other filth are picked out with a picker, (small iron nippers): this occasions a considerable number of apertures, which are all closed by the next process.

9. *Milling.* The cloth is now milled, or scoured with soap till it acquires a proper consistency, it is passed again through the stock to clear it of the soap.

10. *Rowing* or *Dressing.* In Gloucestershire the teazle is used, in this process, by a machine called a Gig-mill, which smoothes the cloth and raises the nap; but in some places it is still done by the hand.

11. *Shearing* is performed by a machine. The shearman passes it over the cloth sometimes more than once; even five or six times, if the nap be not sufficiently out, according to the substance of the cloth.

12. *Dyeing.* See the next Section.

13. *Streaming.* After being dyed, the cloth is washed in running water. Black, blue, and green cloths are often sheared again, after they are taken off the tenters, but not scarlet and white, as those colours are apt to soil in the operation. The shearman now hangs it on the tenters; where it is stretched in length and breadth to smooth it, and bring it to its dimensions, without straining it too much. It is now brushed the way of the hair, while moist on the tenter.

14. *Pressing.* When quite dry, the cloth is taken from the tenter and brushed with a machine called a brusher *, to finish the laying of the nap. It is then folded and laid under

* Fine cloths are never brushed.

a press, to make it perfectly smooth and even, and to give it a gloss.

The chief clothing countries in England, are Gloucestershire for blacks, scarlets, and kerseymeres; Wiltshire for blues, medleys, and mixtures for home sale; and Yorkshire for coarse cloths, for exportation.

297. *Calamanco.* This is a woollen stuff, manufactured in England and Flanders. It has a fine gloss, and is checkered in the warp, whence the checks appear only on the right side. Some calamancoes are quite plain, others have broad stripes, some narrow stripes, and others are watered.

The Manufacture of Silk.

298. So great is the importance of silk in a commercial view, that in most of the eastern countries of the world a close attention is paid to the growth and cultivation of the insects by which it is produced.

Each moth lays about two hundred small straw-coloured eggs. As soon as the worms are hatched, they are fed with the tenderest leaves of the mulberry-tree, or with these leaves chopped very fine; and when they have attained sufficient strength, they are removed into wicker baskets, or placed upon shelves made of wicker-work. Here they are fed for about thirty days, until they are full grown, when they are furnished with little bushes of heath or broom. On these they spin the nests in which they are about to change into crysalids. These nests have the general name of coccoons, and consist of somewhat oval-shaped balls of silk, of marigold colour. The exterior of the coccoon is composed of a rough cotton-like substance, called floss. Within this is the thread which is more distinct and even, and appears arranged in a very irregular manner, winding off first from one side of the coccoon, and then from the other. Previously to the silk being wound from the coccoons, they are baked for about an hour to kill the crysalids they contain. When the silk is to be wound off, the coccoons are put into small coppers or basons of water, each placed over a small fire. The ends of the threads are found by brushing the coccoons gently with a whisk made for the purpose; and so fine are these threads, that eight or ten of them are generally rolled off into one. In winding them, they are each passed through a hole in an horizontal iron bar, placed at the edge of the bason, which prevents them from being entangled.

299. The culture of silk was anciently confined to China. Britain, however, possesses some advantages over warmer countries for raising silk, although this article is generally imported from the latter. The manufacture of silk is carried on to a great extent at Derby; the number of hands to which it affords employment, being upwards of one thousand, including children and women. The original mill, called the silk-mill, by way of distinction, is the first and largest of its kind in England, and stands upon an island in the river Derwent. The introduction of this manufacture into England, was attended with some circumstances of an interesting nature, and of which we shall give the reader a brief account.

The Italians were long in exclusive possession of this art. About the year 1715, John Lombe formed a resolution of visiting Italy, to procure drawings or models of the machinery necessary for the undertaking; but as admission to the Italian silk works was prohibited, he could only obtain access by corrupting two of the workmen. Through their assistance he inspected the machinery in private; and whatever parts he obtained a knowledge of during these visits, he recorded on paper, before he slept. By perseverance in this mode of conduct, he made himself acquainted with the whole; and had just completed his plan, when his intention was discovered, and his life being in extreme hazard, he fled with precipitation, and took refuge on ship-board, accompanied by the two Italians who favoured his scheme; they all landed in England about the year 1717. Lombe then erected his mills at Derby, and the following is a brief account of these mills.

300. The extensive fabric, which contains the machinery, stands upon piles of oak, doubly planked, and covered with stone-work, on which are turned 13 stone arches, that sustain the walls. Its length is 110 feet; its breadth thirty-nine; and its height fifty-five feet six inches. It contains five stories besides the under works, and is lighted by 468 windows.

In the three upper stories are the Italian winding engines, which are placed in a regular manner, across the apartments, and furnished with many thousand swifts and spindles, and engines for working them. In the two lower rooms are the spinning and twist mills, which are all of a circular form, returned by upright shafts, passing through their centres, and communicating with shafts from the water wheel. Their diameter is between twelve and thirteen feet; and their height nineteen feet eight inches. The spinning mills are eight in number, and give motion to upwards of 25,000 reel bobbins and nearly 3000 star wheels belonging to the reels. Each of the four twist mills contains four rounds of spindles, about 389 of which are connected with each mill, as well as numerous reels, bobbins, star-wheels, &c. The whole of this elaborate machine, for one only it is, though distributed, as we have mentioned, through five large departments, is put in motion by a single water-wheel, twenty-three feet in diameter, situate on the west side of the building.

All is whirling and in motion, and appears as if directed and animated by some invisible power; yet mutually dependent as every part is, any one of them may be stopped and separated at pleasure. This arises from every movement being performed by two wheels, one of which is turned by the other; but when separated, the latter preserves his rotatory motion, while the other stops, as the impelling power no longer operates. The whole number of wheels is about 14,000. There is a model of this work in the Tower.

The Manufacture of Cotton Cloth.

301. The cotton, from which cotton cloth is made, is a soft downy substance, produced from the cotton-tree. The cotton used in the British manufactories, is chiefly brought from the West-Indies, where it is found in the seed-pod almost fit for manufacturing. The cotton which is imported is first picked, and then carded; by a combination of machinery, which also weaves and spins it with the utmost degree of exactness and equality. The principal machines worth notice, are the Mule and the Jenny. The latter machine has been so much improved that one person may spin 100 English hanks of cotton yarn per day, each of which consists of 840 yards.

After being spun, cotton is next woven in a loom; by a very simple process. The threads in the length are called the warp; and are drawn tight by weights at one end, at the other end they are divided into two sets, each composed of alternate threads. On a threadle being moved, by the foot, one set, or every other thread, is thrown up, and the other brought down, and at this instant a cross thread or woof is thrown between them by means of a shuttle. The respective ends are then raised, the others are brought down, and the woof is thrown between, the operations continuing till the whole length of the warp has been interwoven by the woof or cross threads.

The forms of looms are various, and often intricate. There are stocking looms, or frames, silk looms, cloth looms, cotton looms, &c. &c. When the piece has been woven, it requires to be bleached by the air and sun, or by exposure to some acid. It is afterwards printed, if desired, by means of blocks of wood, cut out to the pattern; and pressed and glazed before it is offered for sale. We have in another place explained the principles of bleaching, and the process of calico printing.

302. The various kinds of cotton cloth are the following. Muslin, a loose woollen cloth of the finest cotton yarn. All muslins were formerly imported from India; but abundance are manufactured in Manchester, Glasgow, and Paisley, which for fineness and durability are not inferior to those of the east, except that the British muslins acquire a yellowish cast after being frequently washed; whereas the genuine India muslins retain their original whiteness.

303. *Calico* is a cotton cloth, so named from Calicut, in India, where it was originally manufactured. Within the last thirty years, it has been imitated in Great Britain, and brought to great perfection since the invention of machines for spinning cotton. There are upwards of 150,000 persons employed in the manufacture of calico and in calico printing in Manchester, Glasgow, and Paisley, alone.

304. *Fustian* is a cotton stuff, wealed or ribbed on one side. It should be made altogether of cotton yarn, both warp and woof; but of most, the warp is flax, or even hemp. There are also wide, narrow, and coarse fustians, some with shag or knap, and others without it. Manchester is the prin-

cipal place for the manufacture of fustians of all kinds.

305. *Gauze* is a thin transparent stuff, sometimes of thread.

The silk is turned round a wooden machine, six feet high, in the middle of which, an axe is placed, with six large wings. On these the silk is wound off in bobbins by the revolution of the axes, when it is thus placed round the mill, it is taken off by another instrument, and wound on two beams. The silk is then passed through as many small beads as it has threads, and is thus rolled on another beam, to supply the loom. Figured gauzes which are worked with flowers of gold and silver on a silk ground, are chiefly imported from China.

306. *Plush* is a sort of stuff having a velvet knap on one side. It is composed regularly of a woof of a single woollen thread and a double warp; the one wool, of two-thirds twisted, the other goat's or camel's hair. But there are some kinds of plush entirely of worsted.

307. *Lace* is composed of many threads of gold, silver, or silk, interwoven the one with the other, and worked upon a pillar with spindles, according to some pattern. The open work is formed with pins, which are placed and displaced, as the spindles are moved. The importation of gold and silver lace is prohibited.

Bone lace is made of fine linen thread, or silk, in the same manner as gold and silver lace. The process is as follows: the pattern of the lace is fixed upon a large round pillow, and pins being stuck into the openings, in the pattern, the threads are interwoven by means of a number of bobbins made of bone or ivory, each of which contain a small quantity of fine thread, in such a manner as to make the lace exactly resemble the pattern. There are several towns in England, and particularly in Buckinghamshire, that carry on this manufacture; but the finest laces are imported from Flanders. At any rate they are in most request among English ladies.

308. *Linen* is made of flax, the produce of an annual plant with spear-shaped leaves, and blue flowers, which is cultivated in several parts of Great

Britain, and grows wild in corn-fields and the sandy pastures of some of our southern counties.

It is supposed that we have been originally indebted for this plant to those parts of Egypt which are annually inundated by the Nile. The time of its first introduction into this country is, however, unknown. Its utility is incalculable. To it we are indebted for the linen we wear, for our sheets, table-cloths, and numerous other indispensable articles; and although cotton might, in some measure, supply its place, those persons who have been accustomed to the comforts of linen would be little desirous of the exchange.

309. *Incombustible Cloth.* This cloth is made of asbestos, a greenish or silvery white mineral, of fibrous texture, found in many mountainous countries, in the island of Anglesea, and in Scotland. It occurs in shapeless masses, and varies much both in weight and hardness.

The name of this mineral is derived from the Greek language, and signifies that which is inconsumable. A silky variety of this mineral, with long slender filaments was well known to the ancients, it was called *amianthus.* They made it into an incombustible kind of cloth, in which they burnt the bodies of their dead, and were thereby enabled to collect and preserve the ashes without mixture. In the manufacture of this article they were not able to weave the asbestos alone, but in the loom were obliged to join with it linen or woollen threads, which were afterwards burnt away.

Incombustible cloth was purchased by the Romans at an enormous expense. There is a winding-sheet of asbestos in the Museum of the Vatican at Rome. It is coarsely spun, but as soft and pliant as silk. This interesting relic was discovered in the year 1702, in a funeral urn, and contained burnt bones, together with a quantity of ashes. It is nine Roman palms long, and about seven in width, and was deposited in the library of the Vatican by order of Pope Clement the Eleventh.

Cloth made of amianthus, when greased, or otherwise contaminated with dirt, may be cleansed by throwing it into a bright fire. In this process the stains are burnt out, and the cloth is restored to a dazzling white colour. Pliny, the Roman naturalist, informs us that he had himself seen table-cloths, towels, and napkins of amianthus taken from the table of a great feast, thrown into the fire, and burnt before the company; and by this operation, he says, they became better cleansed than if they had been washed.

The shorter fibres of amianthus have sometimes been manufactured into paper; and the longer threads have been used as incombustible wicks for lamps. Kircher, the German philosopher, had a wick made of amianthus which burnt for two years without injury, and was at last destroyed by accident.

SECTION II.

THE DYEING OF CLOTHS.

310. Dyeing is the art of tinging cloth, stuff, or other matter, with a permanent colour, by penetrating its substance. It is, however, usually confined to the art of imparting different colours to wool, silk, linen, &c. The substances employed for this purpose are called colouring matters or dye-stuffs, and are extracted from animal and vegetable substances. If the colouring matters were merely spread over the surface of the fibres of cloth by the dyer, the colours produced might be bright, but they could not be permanent; because the colouring matter would disappear whenever the cloth was washed or exposed to the weather. The colouring matter cannot seize upon the cloth permanently unless there be an affinity between them. And since there can be no affinity till the dye stuffs have been reduced to their integrant particles, dyeing is a process purely chemical.

The colouring matter is first dissolved in some liquid which has a weaker affinity for it than the cloth has. When the cloth is dipped in this solution, the colouring matter is brought within the attracting distance; the cloth acts upon it, and from its stronger affinity, takes it from the mordant and fixes it upon itself. The equality of the colour is also secured by this contrivance, as every part of the cloth has an opportunity of attracting to itself, the proper proportion of colouring particles.

Wool has the strongest affinity for almost all colouring matters; the next strongest is cotton, which has a considerably weaker affinity, and linen the weakest of all. In order therefore to dye cotton or linen, the dye-stuffs should be dissolved in a substance for which it has a weaker affinity than for the solvent employed in the dyeing of wool or silk. To dye wool, we use *oxyde of iron;* to dye cotton or linen *acetous acids* answer best.

311. *Of Mordants.* To render dyeing colours permanent, a substance called a *mordant* is pitched upon, which has a powerful attachment to both the cloth and the colouring matter. And this substance or *mordant* is previously combined with the cloth, which is then plunged into the solution of dye stuff. The dye stuff combines with the mordant, which being firmly combined with the cloth, secures the permanency of the dye.

The proper preparation and the application of mordants are thence the principal considerations in the art of dyeing. The mordants must be previously dissolved in some liquid, which has a weaker affinity for them than the cloth has to which they are to be applied; and the cloth to saturate itself with the mordant must be dipped or steeped in the solution.

The mordants are *earths; metallic oxydes; tan* and *oil.*

312. *Alumine* is the most important mordant that dyers use. This earth is indispensable to dyers and calico printers, not only on account of its cleansing and opening the pores of the substances to be dyed, and thus rendering them fit to receive the colouring particles, but also from its more essential property of fixing the colours, or that they cannot afterwards be washed out. Alumine is used either in the state of common alum or in that of acetite of alumine.

313. *Lime* is also used as a mordant, either in the state of lime water, or of sulphate of lime dissolved in water.

314. *Of the metallic oxydes*, those of tin and iron are the most generally used; the former gives brightness to such colours as are used in forming reds and scarlets, and it precipitates the colouring matter in other dyes; the latter has a very strong affinity for all kinds of cloth, as is proved abundantly by the difficulty we have to remove iron spots (moulds) from linen or cotton cloth. And as a mordant it is used either as sulphate of iron or acetite of iron.

315. *Tan and Oil.* On the leaves and buds of the oak certain excrescences are formed, in consequence of the puncture of insects, as a lodgment for their eggs and a habitation for their future young. These are termed *galls*, and if, when arrived at a certain state, they are infused in a weak solution of vitriol, they impart to it a purple or violet tinge: and after the whole colouring matter is extracted, this becomes perfectly black. Considerable quantities of galls are used in dyeing, and for other purposes. Tan adds to the weight of silk, and is therefore much used, oil is also used for the same purpose.

316. Besides these, *tartar*, *acetite of lead*, *common salt*, *sal ammoniac*, *sulphate* or *acetite of copper* are used as mordants.

317. Mordants not only render the dye permanent, but have also considerable influence on the colour produced. The same colouring matter produces very different dyes, according as the mordant is changed. Suppose, for instance, that the colouring matter be cochineal; if we use the aluminous mordant, the cloth will acquire a crimson colour; but the oxyde of iron produces with it a black.

In dyeing then, it is not only necessary to procure a mordant which has a sufficiently strong affinity for the colouring matter and the cloth, and a colouring matter which possesses the wished for colour in perfection, but we must procure a mordant and a colouring matter of such a nature, that when combined together, they shall possess the wished for colour in perfection. It is evident too, that a great variety of colours may be producedwith a single dye stuff, provided we can change the mordant sufficiently.

The colouring matter with which the cloth is dyed, does not cover every portion of its surface: its particles attach themselves to the cloth at certain distances from each other; for cloth may be dyed different shades of the same colour, lighter or darker, merely by varying the quantity of colouring matter. With a small quantity, the shade is light; and it becomes deeper as the quantity increases; now this would be impossible, if the dye stuff covered the whole of the cloth.

That the particles of colouring matter even when the shade is deep, are at some distance, is evident from this well known fact, that cloth may be dyed two colours at the same time. All those colours to which the dyers give the name of *compound*, are in fact two different colours applied to the cloth at once. Thus cloth gets a *green* colour, by being first dyed *blue* and then *yellow*.

318. The colours denominated by dyers, *simple*, because they are the foundation of all their other processes, are four; namely, first, *blue*; second, *yellow*; third, *red*; fourth, *black*. To these they usually add a fifth, under the name of *root*, or *brown* colour.

319. *To dye blue.* The substances principally used in this dye, are indigo and woad, with which every kind of cloth may be dyed without a mordant.

Indigo is brought from the West-Indies. It is drawn from the leaves of a plant called *anil*.

When the plant has arrived at a certain height, it is cut, thrown into a vat, and covered with water. A scum rises to the top, of various colours. The water is let off into another vessel, where it is churned with poles, till the water appears of a deep green, and till the grain, as it is called, forms itself. This is discovered by taking a little of it into another vessel and spitting in it, for then if a bluish dreg subside, it is not beaten any more. The matter is then precipitated, and the water poured off. It is then put into linen bags to drain, and when dry, cut into slices, and hardened in the sun.

Woad is obtained from the leaves of a plant, which when ripe, are gathered and suffered to lie some time, and then put under the wheel to be bruised or ground; after this they are laid eight or ten days in piles or heaps; and at last made up into balls, which are laid in the shade, on hurdles, to dry. The balls are then pulverized, spread upon the ground and watered: it smokes and heats till it becomes dry; it is then fit for use. The ancient Britons dyed their bodies with this substance.

Cæsar, Pliny, and Herodian, mention the British practice of body-painting. "All the Britons stain themselves with woad, which makes their skins of a blue colour. They draw upon their naked bodies the figures of animals of all kinds, which they esteem so great an ornament, that they wear no clothes, that these figures may be exposed to view." We learn from other authors, that this body-painting was a distinct trade or profession in those times; and that the artist began his work by making the intended figures upon the skin with the punctures of sharp needles, that it might the better imbibe and retain the colouring. This is said to have been a very painful operation. When these figures were made on the body in childhood, as they commonly were, they grew and enlarged with it, and continued upon it through life. Persons of inferior rank had but few of these figures, of a small size, and coarse workmanship, painted on their bodies; but those of better families had them in greater numbers, of larger dimensions, and more elegantly executed, according to their different degrees of nobility. The name of the Picts, says Isidorus, corresponds very well with the appearance of their bodies; for they squeeze the juice of certain herbs into figures made on their bodies with the points of needles, and so carry the badges of their nobility on their spotted skins.

A wood-blue is a very deep blue, almost black; and is the base of so many sorts of colours, that the dyers have a scale by which they compose the different casts, or degrees of woad.

320. *Process*. When *wool, cotton*, or *silk* is intended to be dyed, the cloth is first wetted with hot water and wrung out; then it is immersed in a clear dye-liquor, and remains therein according to the shade wished for; it comes out green, but soon turns blue on being exposed to the air.

321. *Cotton* intended to be dyed blue is first passed through water, containing sulphuric acid. Silk is

dyed a light blue by a ferment of six parts of bran, six of indigo, six of potash, and one of madder. But cotton and linen are dyed blue by a solution of one part of indigo, one of green sulphate, and two parts of quick-lime.

322. *To dye red.* The process of dying red requires a peculiar preparation of the stuffs, on the exactness of which the goodness and permanency of the colour depend. These preparatory ingredients consist of alum, tartar, nitric acid, or a solution of tin in nitric acid. Galls and alkaline salts are also sometimes added.

323. The *Carthamus Tinctorius* plant, a native of Egypt and the Levant, gives a poppy, cherry, and rose-red, and flesh colour to silk, and is also employed in making rouge. This last is made by precipitating with lemon juice, the red colouring matter extracted by carbonate of soda. *Madder* is the root of a plant called *rubia tinctorium.* Alum and tartar are employed in the preparation of the ingredients for this red. *Cochineal* consists of an insect which is collected round the Indian fig-tree, and is found abundant in South America.

It is nourished solely by the juice of the plant on which it breeds, and which becomes converted into its substance, yielding a most beautiful scarlet and crimson colour. The cochineal insects are gathered in the beginning of August, when they are killed, by immersing them in hot water, putting them into an oven moderately heated for that purpose; or exposing them to the scorching rays of the sun. More than one million of pounds weight of this drug are annually imported into Europe.

Kermes is an insect about the size of a juniper berry, round, smooth, and glossy; of a *beautiful red* colour, and full of a juice of the same dye.

It is found adhering to the bark, on the stem and the branches of a small oak, growing in Spain, Languedoc, and other countries. This colour is the most permanent, but the least bright; it is apt also to be less spotted than the others; but, on account of the difficulty of procuring the insects which afford the colour, it is very seldom used in Britain.

324. *Logwood* and *Brazil-wood* are also used for red dyes, but the colour is not durable. The latter grows in the warmest parts of South America.

It is of a red colour, and very heavy. It is usually found in dry barren places, and in the fissures of rocks; it is very thick and large; knotted and crooked; and its flowers, which are of a beautiful red, exhale an agreeable odour. Logwood is found in the Bay of Campechy. Alcohol best extracts the colouring matter of the logwood.

325. *Of dyeing yellow.* The principal colouring matters for dyeing yellow are weld, fustic, and quercitron bark.

Weld is a tribe, which grows wild in barren and uncultivated places, particularly on coal-pit banks, in several partsof England.

The leaves are spear-shaped, and entire, with a tooth-like process on each side of the base. The flowers are yellow, and in long spikes; and the calyx is divided into four segments.

In some parts of England, particularly in the clothing counties, weld is cultivated to a great extent, and it flourishes in sandy soils that could be turned to little advantage in any other way.

Fustic is the wood of a large tree which grows in the West-Indies.

Quercitron is a tree growing naturally in North America, the bark of which contains colouring matter.

Yellow colouring matters have too weak an affinity for cloth, to produce permanent colours without the use of mordants. Cloth, therefore, before it be dyed yellow, is always prepared by combining some mordant or other with it.

The mordant most commonly employed for this purpose, is alumine. Oxyde of tin is sometimes used for fine yellows. Tan is often employed as a subsidiary to alumine, and in order to fix it more copiously on cotton and linen. Tartar is also used to brighten the colour: and muriate of soda, sulphate of lime, and even sulphate of iron to render the shade deeper.

The yellow dyed by means of fustic is more permanent, but not so beautiful as that by weld or quercitron. As it is permanent, and not much injured byaoids, it is used in dyeing compound colours, where yellow is required. The mordant is alumine. When the mordant is oxyde of iron, fustic dyes a permanent drab colour.

Weld and quercitron bark yield nearly the same colour; but as the bark yields colouring matter in much greater abundance, it is more convenient, and cheaper than weld. The method of using each of the dye stuffs is nearly the same.

326. To dye *wool* yellow. Boil the wool for an hour or more with about one-sixth of its weight of alum, dissolved in a sufficient quantity of water. Then plunge it, without being rinsed, into a bath of warm water, containing as much quercitron bark as equals the weight of the alum employed as a mordant. The cloth must now be turned through the boiling liquid, till it has acquired the intended colour. Then a quantity of clean powdered chalk, equal to $\frac{1}{10}$ part of the weight of the cloth, is to be stirred in, and the operation of dyeing continued for eight or ten minutes longer. By this method a pretty deep and lively yellow may be given fully as permanent as weld yellow.

For very bright orange yellow, it is necessary to have recourse to the oxyde of tin as a mordant: and to produce bright golden yellows, some alum must be added along with the tin. But to give the yellow a delicate green shade much admired, tartar must be added in different proportions, according to the shade. And by adding a small proportion of cochineal, the colour may be raised to a fine orange, or even an aurora.

327. *Silk* may be dyed different shades of yellow, either by weld or quercitron bark, but the last is the cheapest of the two.

The proportion should be from one to two parts of bark to twelve parts of silk, according to the shade. The bark, tied up in a bag, should be put into the dyeing vessel, while the water which it contains is cold; and when it has acquired the heat of about 100 degrees, the silk, having been previously alumed, should be dipped in, and continued till it assumes the wished for colour. When the shade is required to be deep, a little chalk or pearl-ash should be added towards the end of the operation.

328. *Cotton* and *linen* are dyed yellow, thus: the mordant should be acetite of alumine, prepared by dissolving one part of acetite of lead, and three parts of alum, in a sufficient quantity of water. This solution should be heated to the temperature of 100 degrees, the cloth soaked in it for two hours, then wrung out and dried. The soaking may be repeated, and the cloth again dried as before. It is then to be barely wetted with lime water, and afterwards dried. The soaking in the acetite of alumine may be again repeated, and if the shade of yellow is required to be very bright and durable, the alternate wetting with lime water and soaking in the mordant may be repeated three or four times.

By this contrivance, a sufficient quantity of alumine is combined with the cloth, and the combination is rendered permanent by the addition of lime. The dyeing bath is prepared by putting 12 or 18 parts of quercitron bark (according to the depth of the shade required,) tied up in a bag, into a sufficient quantity of cold water. Into this bath the cloth is put, and turned round in it for an hour, while its temperature is gradually raised to 120 degrees; it must be then brought to a boiling heat, and after that the cloth allowed to remain in it, only a few minutes. If it be kept long at a boiling heat, the yellow acquires a brown shade.

Nankeen yellow is obtained by a solution of the red sulphate of iron, which is combined with the cloth by carbonate of potash.

329. *To dye fawn colour.* The process of dying this colour differs from others, the wool merely requiring a simple immersion in water.

Various substances are used for dyeing brown or fawn colour. 1. The bark or rind of the *walnut-tree.* Its shades are uncommonly fine; its colours solid; and it renders the wool flexible and soft. A cauldron half full of water is placed over the fire; as soon as it grows warm, bark is added in proportion to the quantity of stuffs intended to be dyed, and the lightness or depth of the shades required. It is then boiled for a quarter of an hour, when the cloths, previously moistened with warm water, are immersed, frequently turned, and well stirred, till they have sufficiently imbibed the colour. They are then dried and dressed in the usual manner.

The *root* of the walnut-tree is also employed, but with a different process. When the green *walnut-shells* are used, they are collected when the nuts are ripe; and are put into casks, which are afterwards filled with water, and thus preserved till the succeeding year.

The bark of the *alder-tree* is chiefly used for worsted, imparting shades darkened with copperas. It is also used for wool that is not required to be very dark, as it equally withstands the effects of the sun and rain.

Sanders-wood is much inferior to walnut-shells; stiffens, and consequently injures the wool. It is in general mixed with galls, sumach, and alder-bark, without which its colour could not be extracted.

Sumach where dark colours are required, is frequently substituted for nut-galls, in which case a greater proportion becomes necessary.

These different substances, however, are not unfrequently mixed together, they are of a similar nature, differing only in a degree of colour, and it is easy to obtain various shades. It is both solid and permanent.

Soot is only used when the other ingredigents cannot be procured. It is not only less solid than the others, but also hardens, and imparts a very disagreeable smell to the wool or stuff.

330. *To dye black.* To dye cloth black, red oxyde of iron and tan are employed, log is used as an auxiliary, because it communicates lustre, and adds to the fullness of the black.

1. *Cloth,* before it receives a black colour, is dyed blue; but if the cloth be coarse, the blue dye is expensive; in that case walnut-peels are used to give it a brown colour.

2. *Wool* is boiled for two hours in a decoction of nutgalls, then kept two hours more in a bath of logwood and sulphate of iron, at a scalding heat, but not boiled. It must be frequently exposed to the air during the process, to imbibe oxygen before the cloth can acquire a proper colour.

3. *Silk* is dyed nearly in the same manner, but as it is capable of combining with a great deal of tan the quantity given is varied at the pleasure of the artist, by allowing the silk to remain a longer or shorter time in the decoction.

4. *Linen* and *cotton* previously dyed *blue*, are steeped for twenty-four hours in a decoction of nut-galls, mixed with a decoction of alder-bark. A bath is prepared, containing an acetite of iron. Into this bath the cloth is put in small quantities at a time, wrought with the hand for a quarter of an hour, then wrung out, and aired again; wrought in a fresh quantity of the bath, and afterwards aired. These processes are repeated, till the requisite colour has been given to the cloth.

331. *Of dyeing compound colours.* Compound colours are produced by mixing two simple colours together; or, by dying cloth first one simple colour, and then another. These colours vary to infinity, according to the proportions of the ingredients employed, and may be arranged under the following classes.

Mixtures of 1. Blue and yellow; 2. Blue and red; 3. Yellow and red; 4. Black and other colours.

332. *Mixtures of blue and yellow.* This forms *green*, which is distinguished by dyers into a variety of shades, according to the depth of the shade, or the prevalence of either of the component parts. Thus we have *sea-green*, *grass-green*, *pea-green*, &c

Wool, silk, and linen, are usually dyed green, by giving them first a blue colour, and afterwards dying them yellow; because, when the yellow is first given, several inconveniences follow: the yellow partly separates again in the blue vat, and communicates a green colour to it, and thus renders it useless for every other purpose, except dying green. Any of the usual processes for dyeing blue and yellow may be followed, taking care to proportion the depth of the shades to that of the green required. When sulphate of indigo is employed, it is usual to mix all the ingredients together, and to dye the cloth at once; this produces what is known by the name of *Saxon* or *English green.*

333. *Mixtures of blue and red.* These form different shades of *violet, purple,* and *lilac.* Wool is generally first dyed blue, and afterwards scarlet, in the usual manner.

If cochineal be mixed with sulphate of indigo, the process may be performed at once. Silk is first dyed crimson by means of cochineal, and then dipped into the indigo vat. Cotton and linen are first dyed blue, then galled, and soaked in a decoction of logwood; but a more permanent colour is given by oxyde of iron.

334. *Mixtures of yellow and red.* This produces *orange.* When blue is combined with red and yellow on cloth, the resulting colour is *olive.* Wool may be dyed orange, by first dying it scarlet, and then yellow. When it is dyed first with madder, the result is *cinnamon colour.*

Silk is dyed orange by means of carthamus; a cinnamon colour by logwood, Brazil-wood, and fustic mixed together.

Cotton and linen receive a cinnamon colour by means of weld and madder; and an olive colour, by being passed through a blue, yellow, and then a madder bath.

335. *Mixtures of black with other colours.* These constitute *greys, drabs,* and *browns.* If cloth be previously combined with brown oxyde of iron, and afterwards dyed yellow with quercitron bark, the result will be a *drab* of different shades, according to the proportion of mordant employed.

When the proportion is small, the colour inclines to olive or yellow; on the contrary, the drab may be deepened or saddened, as the dyers term it, by mixing a little sumach with the bark.

SECTION III.

CALICO PRINTING.

336. *Calico-printing,* or the art of applying coloured patterns, on a white or coloured ground of linen or cotton has been practised in India, for

more than two thousand years, but has not been cultivated in Europe more than a century. This art depends on the action of certain bodies, which, by chemical agency, permanently unite the colouring matter of dyeing materials, to particular parts of the cloth.

The substances which bind the colouring matters to the fibres of the cloth, are denominated mordants. The mordant is applied to the cloth, by wooden blocks, in which the patterns are carved in relief. This effect is also produced by means of a small brush, by sheet copper fixed in a block, like fillagree work, or by the copper-plate.

When the mordants have been applied, the cloth is made completely dry; and washed in water, till the thickening matter, and those parts of the mordants, uncombined with the cloth, are removed. After this the cloth is rinsed in clean water. It is then dipped in the dye liquor, by which the whole is dyed. The parts which have been impregnated with the mordant, receive a brighter colour than those which have not. The colour of the former is permanent, but that of the latter is discharged by repeated washing.

337. Calico-printing, we have said, consists in impregnating those parts of the cloth which are to receive a colour, with a mordant, and then dyeing it as usual with some dye stuff or other. The dye stuff attaches itself firmly to that part of the cloth only which has received the mordant. The whole surface of the cotton is indeed more or less tinged, but by washing and bleaching, all the unmordanted parts resume their original colour, while those which have received the mordant retain it.

Let us suppose that a piece of white cotton cloth is to receive red stripes; all the parts where the stripes are to appear are pencilled over with a solution of acetite of alumine; after this, the cloth is dyed in the usual manner with madder. When taken out of the dyeing vessel it is all of a red colour, but by washing and bleaching, the madder leaves every part of the cloth white, except the stripes impregnated with the acetite of alumine, which remain red. Thus it is obvious that it is not the cloth but the mordant which has retained the dye. In the same manner may yellow stripes, or any other wished-for figure, be given to cloth, by substituting quercitron bark, weld, &c. for madder.

338. When different colours are to be given to different parts of the cloth at the same time, it is done by impregnating it with various mordants.

Thus, if stripes be drawn upon a cotton cloth with acetite of alumine, and other stripes with acetite of iron, and the cloth be afterwards dyed in the usual way with madder, and then washed and bleached, it will be striped *red* and *brown*. The same mordants with quercitron bark, give *yellow* and *olive*, or *drab*.

339. The mordants employed in calico-printing are acetite of alumine, and acetite of iron, prepared in the manner already described. These mordants are applied to the cloth, either with a pencil, or by means of blocks. As the mordants are applied only to particular parts of the cloth, care must be taken that none of them spread to the part of the cloth which is to be left white, and that they do not interfere with one another when more than one are applied. If these precautions be not attended to, all the elegance and beauty of the print will be destroyed.

It is necessary, therefore, that the mordants should be of such a consistence, as not to spread beyond those parts of the cloth on which they are applied. This is done by thickening them with flour or starch, when they are to be applied by the block; and with gum-arabic, when they are to be put on by a pencil. The thickening should never be greater than is sufficient to prevent the spreading of the mordants; when carried too far, the cotton is apt not to be sufficiently saturated with the mordants; and of course the dye takes but imperfectly.

In order that the parts of the cloth impregnated with mordants may be distinguished by their colour, it is usual to tinge the mordants with some colouring matter or other. The printers commonly use the decoction of Brazil-wood for this purpose; but the Brazil-wood colouring matter impedes the subsequent process of dyeing. The mordant should therefore be coloured with some of the dye stuff afterwards to be applied; but not more than is sufficient to make the mordant distinguishable when applied to the cloth. The reason is obvious. If too much dye be mixed with the mordant, a great proportion of the mordant will be combined with colouring matter, which must weaken its affinity for the cloth, and of course prevent it from combining with it, in sufficient quantity to ensure a permanent dye.

Sometimes these two mordants are mixed together in different proportions; and sometimes one or both is mixed with an infusion of sumach, or of nut-galls. By these contrivances, a great variety of colours are produced by the same dye stuff.

After the mordants have been applied, the cloth is dried by artificial heat, which contributes towards the separation of the acetous acid from its base, and towards its evaporation, by which the mordant combines in a greater proportion, and more intimately with the cloth.

When the cloth is sufficiently dried, it is to be washed with warm water and cow-dung, till all the flour, or gum, employed to thicken the mordants, and all those parts of the mordants which are uncombined with the cloth, be removed. After this, the cloth is thoroughly rinsed in clean water. Almost the only dye stuffs employed by calico-printers, are indigo, madder, and quercitron bark, or weld. This last substance, however, is but little used by the printers of this country, except for delicate greenish yellows. The quercitron bark has almost superseded it, because it gives colours equally good, and is much cheaper and more convenient, not requiring so great a heat to fix it. Indigo not requiring any mordant, is commonly applied at once, either with a block or a pencil. It is prepared by boiling together indigo, potash made caustic by quick-lime, and orpiment; the solution is afterwards thickened with gum. It must be carefully secluded from the air, otherwise the indigo would soon be regenerated, which would render the solution useless. Coarse brown sugar as a substitute for orpiments, is equally efficacious in decomposing the indigo, and rendering it soluble; while it likewise serves all the purposes of gum.

When the cloth, after being impregnated with the mordant, is sufficiently cleansed, it is dyed in the usual manner, and the whole is more or less tinged with the dye stuff. It is well washed, and then spread out for some days on the grass, and bleached with the wrong side uppermost. This carries the colour off completely from all the parts of the cotton which have not imbibed the mordant, and leaves them of their original whiteness, while the mordanted spots retain the dye as strongly as ever.

340. We will now give some examples of the manner in which printers give particular colours to calicoes. Some calicoes are only printed of one colour,

others have two, others three or more, even to the number of eight, ten, or twelve. The smaller the number of colours, the fewer in general are the processes.

341. One of the most common colours on cotton prints is a kind of nankeen yellow, of various shades down to a deep yellowish brown, or drab. It is usually in stripes or spots. To produce it, the printers besmear a block, cut out into the figure of the print, with acetite of iron, thickened with gum or flour; and then apply it to the cotton, which, after being dried and cleaned in the usual manner, is plunged into a potash ley. The quantity of acetite of iron is always proportioned to the depth of the shade.

342. For yellow, the block is besmeared with acetite of alumine. The cloth, after receiving this mordant, is dyed with quercitron bark, and then bleached.

343. Red is communicated by the same process; only madder is substituted for the bark.

344. The fine light blues which appear so often on printed cottons, are produced by applying to the cloth a block besmeared with a composition, consisting partly of wax, which covers all those parts of the cloth which are to remain white. The cloth is then dyed in a cold indigo vat; and after it is dry, the wax composition is removed by hot water.

345. Lilac flea brown, and blackish brown, are given by means of acetite of iron; the quantity of which is always proportioned to the depth of the shade. For very deep colours, a little sumach is added. The cotton is afterwards dyed in the usual manner with madder, and then bleached.

346. Dove colour and drab, by acetite of iron and quercitron bark.

Example. When different colours are to appear in the same print, a greater number of operations are necessary. Two or more blocks are employed, upon each of which, that part of the print only is cut, which is to be of some particular colour. These are besmeared with different mordants, and applied to the cloth, which is afterwards dyed as usual. Let us suppose, for instance, that these blocks are applied to cotton, one with acetite of alumine, another with acetite of iron, a third with a mixture of those two mordants, and that the cotton is then dyed with quercitron bark, and bleached. The parts impregnated with the mordants would have the following colours:

Acetite of alumine,	Yellow.
——— iron	Olive, drab, dove.
The mixture,	Olive green, olive.

If part of the yellow be covered over with the indigo liquor, applied with a pencil, it will be converted into *green*. By the same liquid, blue may be given to such parts of the print as require it.

Example. If the cotton be dyed with madder, instead of quercitron bark, the print will exhibit the following colours:

Acetite of alumine,	Red.
——— iron,	Brown, black.
The mixture,	Purple.

When a greater number of colours are to appear; for instance, when those communicated by bark, and those by madder, are wanted at the same time, mordants for part of the pattern are to be applied; the cotton is then to be dyed in the madder bath, and bleached; then the rest of the mordants, to fill up the pattern, are added, and the cloth is again dyed with quercitron bark, and bleached. The second dyeing does not much affect the madder colours; because the mordants, which render them permanent, are already saturated. The yellow tinge is easily removed by the subsequent bleaching. Sometimes a new mordant is also applied to some of the madder colours, in consequence of which, they receive a new permanent colour from the bark. After the last bleaching, new colours may be added by means of the indigo liquor.

The following table will give an idea of the colours, which may be given to cotton by these complicated processes.

1. *Madder Dye.*

Acetite of alumine,	Red.
——— iron,	Brown, black.
——— diluted,	Lilac,
Both, mixed,	Purple.

2. *Bark Dye.*

Acetite of alumine,	Yellow.
———— iron,	Dove, drab.
Lilac and acetite of alumine.	Olive.
Red and acetite of alumine,	Orange.

3. *Indigo Dye.*

Indigo,	Blue.
Indigo and yellow,	Green.

Thus no less than twelve colours may be made to appear together in the same print, by these different processes.

These instances will serve to give the reader an idea of the nature of calico-printing, and at the same time afford an excellent illustration of the importance of mordants in dyeing.

Were it possible to procure colours sufficiently permanent, by applying them at once to the cloth by the block or the pencil, as is the case with the mordants, the art of calico-printing would be brought to the greatest simplicity; but at present, this can only be done in one case, that of indigo; every other colour requires dying. Compositions, indeed, may be made, by previously combining the dye stuff and the mordants.

Thus *yellow* may be applied at once, by employing a mixture of the infusion of quercitron bark and acetite of alumine; *red*, by mixing the same mordant with the decoction of alumine, and so on. The colours applied in this way, are, unfortunately, far inferior in permanency to those produced when the mordant is previously combined with the cloth, and the dye stuff afterwards applied separately. In this way are applied almost all the fugitive colours of calicoes, which washing, or even exposure to the air, destroys.

CHAPTER X.

SECTION I.

BLEACHING.

347. Bleaching is an art which has been cultivated from time immemorial. As now practised, it is divided into two distinct branches; the bleaching of *vegetable,* and of *animal* substances. These being of different natures, require different processes for whitening them. Vegetables, consist of oxygen, hydrogen, and carbon, of which the latter is in the greatest proportion; animal substances, besides these, contain a large quantity of azote, with phosphorus and sulphur.

348. *To Bleach Flax and Hemp.* If ripe flax or hemp be examined, they will be found to consist of a thin bark, enveloping a green sap, then the fibres or filaments that are used in the making of linen, and within that is the woody part. As the fibrous part only is used in the making of cloth, it must be separated from the other substances.

The *sap,* or succulent part, is composed of extractive principle and water, and the first process is to separate this substance, which holds the filaments together.

As soon as the flax is pulled, it is steeped in *soft* water, until the putrefactive fermentation takes place, with the succulent part, and it must be taken out of the water as soon as the wood breaks easily between the hands, while it is yet green, and before the whole of its sap is separated. Well water, brackish water, and that which flows over gypseous soil, must be avoided, else the putrefaction will be accelerated, and the texture of the fibres injured. It is that a small quantity of salt accelerates animal putrefaction, while a great deal tends to prevent it; and the portion of saline substances held in solution in the water, hastens the corruption of the filaments which it blackens and spoils.

This operation of *watering* the flax, is tedious and noxious; it destroys the fish in any stream that may be used, and the smell of the putrifying plants is offensive. Modern chemistry shortens this process, and performs it with less risk of injuring the flax.

If the stream of a solution of caustic alkali in water be introduced into a chamber about thirty feet square, in which the flax is suspended, it will produce the same effect as watering, in less time, with less expence; and less danger to the flax, which is frequently injured by being too long steeped.

Nothing remains after the watering is completed, but the woody part, a hollow tube of compact flax. To separate these stalks, it must be *kiln dried* to render it brittle, but too much heat must not be applied.

It is next to be *beaten* or *broken*, either by manual labour with mallets on wooden anvils, as in the houses of correction, or by mills for the purpose. By this means the flax is divided into small fibres, and most of the wood reduced to small fragments, which are cleared away by scutching or threshing.

Hackling, the last process, is nothing more than combing the flax in small parcels at a time, through a pile of polished sharp iron spikes.

The spikes are placed pretty close together, in a wooden board; the first hackle is coarse, the second finer, and the third finer again. The process of hackling answers several purposes; it divides the fibres of the flax from each other; it detaches the minute fragments of wood which escaped the scutching, and it separates the tow from the short coarse flax.

The flax is now ready to be *spun* into thread or yarn, which is afterwards manufactured into cloth.

TO BLEACH LINEN CLOTH.

349. The process of bleaching now begins. The linen, as it comes from the loom, is charged with the weaver's dressing, a paste of flour and water, to make it stretch more easily. To discharge this, the linen must be steeped 48 hours in water, till the extraneous substance is decomposed by fermentation. Some bleachers boil the linen in water; but very improperly, for paste is not soluble in boiling water.

When the linen is well washed and rinsed, after the last process, it is of a *greyish white* colour, the fibres of which it is composed are naturally very white.

And to separate matter that discolours the linen, is the business of bleaching. This *grey* substance is of a resinous nature, insoluble in water, and from its intimate union with the very fibres of the flax, it is difficult of separation, even by substances that have a solvent power.

Illustration. Alkaline leys, or solutions of alkali rendered *caustic*, have the property of dissolving resins, and are employed as menstrua for this purpose. Alone they are not sufficient to complete the process of bleaching. What appears a single fibre of flax in grey linen, is composed of a bundle of minute filaments, closely cemented by the resinous matter: therefore the potash first acts upon the resin of the external coating of the filaments, they are thus loosened or separated, and exposed to the further action of the air. The second boiling of potash opens a second layer, and thus successively layer by layer, till the whole is opened to the centre. If the alkaline solution were sufficiently strong to force its way at once to the centre, it would act upon the filaments, and destroy the texture of the cloth. Each filament, after the alkaline process, retains an impregnation of colouring matter, so intimately united as to resist its further action. . This can only be removed by the gradual influence of the atmosphere, according to the old method of bleaching, or by the modern improvement of using oxygenerated muriatic acid.

To explain the principle by which this latter part of the process is effected, we must consider that the resin, which forms the colouring matter of unbleached linen, is composed chiefly of carbon and hydrogen: this is partly dissolved by the alkaline ley, and what remains becomes united to the oxygen of the atmosphere, flying off in the state of carbonic acid gas, or remaining as water.

The great objection to the old manner of bleaching was its tediousness, two or three months being necessary to give the cloth its pure whiteness. The simplicity of the process however, and the scanty apparatus it requires, recommend it to those country people who make their own cloth, particularly in Scotland, and some parts of Ireland.

350. *The Method of Bleaching by the Action of the atmospheric Air.* After steeping the linen as mentioned above, to remove the weaver's dressing, the pieces of cloth are dried, and then submitted to the operation of *bucking*.

For this purpose a ley is prepared, by dissolving a quantity of potash * in soft water, to which some soap is added. This liquor is heated to about 100 degrees, and poured upon the linen. After the cloth is well down in the ley, it is drawn off, heated a little higher, and again poured upon the linen. This operation is repeated at successive intervals, allowing the ley to remain longer each time, moderately increasing the heat for about six hours. The cloth is then left steeping for about four hours, when it is taken out, rinsed, and carried to the fields, where it is spread upon the grass, and secured by pins; water is sprinkled on it, to keep it moist for some hours. After it has lain half a day, the watering is less frequent, and at night it is left to the dews. On the succeeding days it is watered three or four times, if the weather be dry, and then it remains on the field till the air seems to have little effect in whitening. It is then brought back to the coppers and bucked again, with a ley somewhat stronger than the last, rinsed, and again spread in the field. It is thus alternately bucked and watered from ten to fifteen times, according to the state of the weather, making the bucking stronger and stronger, till about the middle, and then weaker and weaker till towards the conclusion of the operation.

It must now be scoured or steeped in some acid liquor. The acid which has been usually employed for souring, is formed by the fermentation of bran and water; sour whey has sometimes been used. But sulphuric acid very much diluted, has been found more convenient, and not more injurious.

The cloths are kept in the souring for about six days, if the liquor be formed of milk or bran, or a less time when sulphuric acid is used. They are then rubbed with soap, particularly the selvages, as these resist most the action of the air. It is again bucked, rinsed, watered, and exposed to the atmosphere, and these processes are successively repeated, till the linen has acquired its proper degree of whiteness

351. *To bleach by the oxygenerated muriatic acid.* The oxygenerated muriatic acid is only a combination of muriatic acid and oxygen.. All vegetable colours are influenced by this acid, and whitened with more or less celerity; the colouring matter undergoes a real but slow combustion, which terminates by

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* It is most economical to render it *caustic* for the purpose of bleaching. This is done by adding quicklime to the mild potash, the former having a stronger affinity for the carbonic acid than the latter. But care must be taken not to use the alkali too strong.

the formation of carbonic acid gas, that escapes into the atmosphere. In whatever manner the oxygenerated muriatic acid is procured, the oxygen adheres to it very weakly, and upon this property depends the possibility of producing speedily in manufactories, that action of bleaching which the atmosphere produces slowly.

For the purposes of bleaching, the oxygenerated muriatic acid is employed in four different ways: first, in the state of gas; secondly, as gas combined with water, or what is called the acid; thirdly, potash is mixed with the acid to condense the gaseous vapour and destroy its suffocating odour; fourthly, oxygenerated muriates, dissolved in water, are employed.

The first method by gas, was never used but for experiment; as the vapour is so noxious, that to breathe it is fatal, and several people fell a sacrifice to their attempts in employing it.

When condensed in water, or in the state of oxygenerated muriatic acid, it was found inconvenient in the large way, on account of the expence and difficulty in constructing the necessary apparatus, and the suffocating vapour which escaped.

The new method of bleaching, by oxygenerated muriatic acid was quickly and successively introduced into the manufactories of Manchester, Glasgow, Rouen, Valenciennes, and Courtnay; and it has since been generally adopted in Great Britain, Ireland, France, and Germany. The advantages that result from this method, which accelerates the process of whitening cottons, linens, paper, &c. to a really surprising degree, in every season of the year can be justly appreciated by commercial people only, who experience its beneficial effects in many ways, but particularly in the quick circulation of their capitals.

To save the expense of first preparing the muriatic acid, you may mix with the oxyde of manganese, muriate of soda or common salt, and sulphuric acid diluted with water. The sulphuric acid acts upon the salt, and disengages from it the muriatic acid, which is oxygenerated by the oxyde of manganese.

The proportions observed, when cotton is to be bleached, are Manganese, 30 parts; Common salt, 80; Sulphuric acid, 60; Water, 120.

For linen-cloth, the proportions are as follow: Manganese, 60 parts; Salt, 60; Sulphuric acid, 50; Water, 50.

The better these substances are combined, the more easily will the acid gas be disengaged by the action of the sulphuric acid.

To ascertain the strength of the acid for bleaching, a solution of indigo in the sulphuric acid is employed. The colour of this is destroyed by the oxygenerated muriatic acid, and, according to the quantity of it that can be discoloured by a given quantity of the liquor, its strength is determined.

Cloth is prepared for immersion in oxygenerated water, by first soaking it in a ley of weak potash, and rinsing it afterwards in water, to free it completely from the weaver's dressing, and the saliva of the spinners.

In this country, machinery is employed for rinsing and beating; the apparatus must be arranged according to the objects to be bleached; the skeins of thread suspended in the tub destined for them, and the cloth rolled upon reels in the apparatus.

When every thing is thus disposed, the tubs are filled with oxygenerated muriatic acid, by introducing a funnel, which descends to the bottom of the tub, in order to prevent the dispersion of the gas. The cloth is wound, or the frame work on which the skeins are suspended, is turned several times, until by taking out a small quantity of the liquor from time to time, and trying it by the test of the solution of indigo, it is judged, that it is sufficiently exhausted. The weakened liquor is then drawn off, and may be again employed for another saturation.

Experience proves that the use of the oxygenerated muriatic acid alone weakened the cloath, and various methods of preventing its noxious effects upon the health of the workmen were tried without success, till it was discovered that an addition of alkali to the liquor, destroyed its suffocating effects, without injuring its bleaching powers. The process began then to be carried on in open vessels, and has since been continued in this manner. The bleacher is now able to work his piece, in the liquor, and to expose every part of them to its action, without risk or inconvenience.

Potash was at first used for this purpose; and although this advantage was unquestionably great, it was diminished by the heavy expense of the alkali, which was entirely lost.

It was afterwards discovered that the oxymuriatic acid might be combined with the alkaline earths, as lime and barytes, and also with magnesia, by this means forming oxymuriates, which were soluble in water, and had the property of bleaching. The oxymuriate of lime is at present used in almost all the bleaching grounds.

If the oxygenerated muriatic acid be passed through lime water, it combines with the lime, and forms oxymuriate of lime; but, as the water can only retain a small portion of lime, to cause a larger quantity of lime to combine with the oxymuriatic acid gas, the lime must be mechanically suspended in the water, into which the gas is made to pass, and agitated, so as to present fresh matter to the gas. By this means the oxymuriate of lime is dissolved in water, and used as a bleaching liquor preferable to the oxygenerated muriatic acid and potash.

At the great bleach-fields in Ireland, four leys of potash are applied alternately with four weeks exposure on the grass, two immersions in the oxygenerated muriate of lime, a ley of potash between the two, and the exposure of a week on the grass, between each ley and the immersions. During summer, two leys, and fifteen days exposure, prepare cloth for the action of the oxygenerated muriate; then three alternate leys, with immersions in the liquor, complete bleaching: nothing then will be necessary, but to wind the cloth through the sulphuric acid.

The oxygenerated muriatic acid gas may also be combined with lime in a dry state, or the water may be evaporated, when it is employed for the formation of oxymuriates, which may then be very conveniently transported to any distance without injury to its detersive power.

The *sulphuret of lime* or the combination of sulphur and lime, which are both cheap articles, answer the purposes of potash in bleaching; it is useful in some cases, in others it will not supersede the use of alkali.

To prepare the *sulphuret of lime* for the purpose of bleaching:

Take sulphur or brimstone, in fine powder, four pounds; lime, well slaked and sifted, twenty pounds; water, sixteen gallons; mix these well, and boil them for half an hour in an iron vessel, stirring them briskly. Soon after the agitation of boiling is over, the solution of the sulphuret of lime clears, and may be drawn off free from the insoluble matter, which rests upon the bottom of the boiler. The liquor, in this state, is of the colour of small-beer, but not so transparent.

Sixteen gallons of fresh water are afterwards poured upon the insoluble dregs in the boiler, to separate the remaining sulphuret from them. When it clears, it is drawn off, and mixed with the first liquor; to these again thirty-three gallons more of water may be added, which will reduce the liquor to a proper standard for steeping the cloth. Thus you have sixty gallons of liquor from four pounds of brimstone.

When linen has been freed from the weaver's dressing, in the manner already described, it is to be steeped in the solution of sulphuret of lime (prepared as we have described) for about twelve or eighteen hours, then it is to be taken out and well washed. When dry, it is to be steeped in the oxymuriate of lime for about fourteen hours, and then washed and dried. To whiten the linen, this process is to be repeated during six alternate immersions in each liquor.

The *rationale* of these processes is the following: The oxygenerated liquor supplies to the cloth the place of the atmospheric air, and this in greater abundance, and in a state which renders its action on the cloth more expeditious and more complete. By the union of the oxygen with the carbon of the cloth, carbonic acid is formed, and flies off; and the cloth becomes white.

352. *To bleach with steam.* The action of steam alone does not bleach, the concurrence of oxygen is necessary to aid the composition of the carbonic acid; for this acid requires for its formation, 28 parts of carbon, saturated with 72 of oxygen; but all the oxygen in the apparatus would not be sufficient to saturate the colouring matter burnt by the alkaline combustion, and converted into carbon; this deficit is supplied by immersion in any oxygenerated liquor whatever, and the dispersion of the elastic fluid thus formed is then facilitated by exposure on the grass.

To bleach cloth in this manner, it must be immersed in a slight alkaline caustic liquor, and placed in a chamber constructed over a boiler, into which is put the alkaline ley which is to be raised into steam. After the fire has been lighted, and the cloth exposed to the action of the steam for a sufficient time, it is taken out, and immersed in the oxygenerated muriate of lime, and afterwards exposed for two or three days on the grass. This operation, which is very expeditious, will be sufficient for cotton; but if linen cloth should still retain a yellow tint, a second alkaline caustic vapour bath, and two or three days on the grass, will be sufficient to give them the necessary degree of whiteness.

For the use of private families, when the linen is dirtied by perspiration or grease, laundresses would do well, to steep it for some time in clear water, made by mixing one quart of quicklime in ten gallons of water, letting the mixture stand twenty-four hours, and then using the clean water drawn from the lime. This whitens beautifully without injuring the cloth. The linen in many families is all washed in this manner. It is to be washed as usual, but will require much less soap to be used.

353. *To bleach cotton.* The manufacture and dyeing of cotton cloth, have already been described. It remains now only to explain the methods used in bleaching it.

To bleach cotton, requires not the same preparations as hemp and flax. The first operation is scouring it in a slight alkaline solution; or, what is better, by exposure to steam. It is afterwards put into a basket, and rinsed in running water. The immersing of cotton in an alkaline ley, how well soever it may be rinsed, always leaves with it an earthy deposit.

Cotton bears the action of acids better than hemp or flax; and time is even necessary before their action can be prejudicial to it. By taking advantage of this property, in regard to bleaching, means have been found to free cotton from the earthy deposit, by pressing it down in a very weak solution of sulphuric acid, and afterwards renewing the acid by washing, lest remaining too long in it, the cotton should be destroyed.

354. *To bleach wool.* The substances produced by the animal kingdom differ essentially from vegetables in their constituent principles. Vegetables serve as nourishment to animals and insects. Animalized by their organs, vegetables acquire other properties. There are bones, blood, muscles, horn, as the claws, feathers on birds; bones, muscles, blood, wool, and horn on sheep, &c. We shall here confine ourselves to wool and silk, the animal substances most generally employed for clothing.

Wool, a kind of hair, with which the bodies of some animals are covered, is composed of filaments or tubes, filled with an oily or medullary substance. The sides of these tubes are perforated with a multitude of small pores, which communicate with a longitudinal tube. By chemical analysis, wool gives a great deal of oil, and carbonate of ammonia; caustic alkaline leys dissolve it entirely. It undergoes no change in boiling water; and scarcely alters when preserved in a place well aired; acids have very little action on it; and when exposed to a strong heat, it enters into fusion.

The little action which acids have upon wool, and its unalterableness in water, even when aided by heat, render it necessary to have recourse to alkaline or saponaceous leys; but its solidity in these salts shews, that great prudence and caution must be employed in their use. In regard to acids, none have been hitherto used but sulphureous acid, obtained in the gaseous state by combustion.

In the preliminary operations to which wool is subjected, a little of its grease is left to secure it from insects. Wool is often freed from the grease by farmers, who wish to sell it at a high price, but in the subsequent manipulations, it is greased before it is combed and spun, and as this fat matter attracts dust, it dirties and thickens the stuffs. The first kind of bleaching wool receives, frees it from these impurities. This operation is called *scouring*.

In manufactories, this operation is generally performed by means of an ammoniacal ley, formed of five measures of river water and one of stale urine; the wool is immersed for about twenty minutes in a bath of this mixture, heated to fifty-six degrees; it is then taken out, suffered to drain, and then rinsed in running water: this process softens the wool, and gives it the first degree of whiteness; it is thrice repeated, after which the wool may be employed. In some places, scouring is performed with water slightly impregnated with soap; and indeed, for valuable articles, this is the preferable process, but it is expensive for articles of less value.

355. *Fulling* the cloth, adds still to the whiteness; and, if an increased degree be necessary, it may be procured by the action of the sulphureous acid; or of the fumes of sulphur in a state of combustion, or the vapour of that acid condensed and combined with water.

356. *Sulphuring* is performed in an arched chamber, constructed in such a manner, that the articles exposed to the action of the sulphur can be suspended.

The chamber being filled, a certain quantity of sulphur is placed in it in a state of combustion in flat dishes, the entrance is shut, and all the interstices around the door stopped to prevent the access of the atmospheric air. The acid, generated by the combustion of the sulphur, penetrates the stuffs, attacks and destroys the colouring matter, and effects the bleaching. The stuffs are left in the stoves from six to twenty-four hours afterwards. They are then taken out, and passed through a slight washing with soap, to remove the roughness they have acquired by the action of the acid, and to give them the necessary softness. But then this process is imperfect. At first, the acid of the sulphur acts only on the surfaces, and does not penetrate. This aerial immersion is not sufficient; the gas cannot introduce itself to a sufficient depth into the stuffs, and the superficies only is whitened.

357. A superior method has been invented, which is by making use of sulphureous acid.

The sulphureous acid, or that acid generated by the imperfect combustion of sulphur, differs from the sulphuric acid (oil of vitriol), by containing less of the acidefying principle. It is the mean between sulphur and the sulphuric.

Sulphureous acid gas unites easily with water, and in this combination is employed for bleaching wool or silk. The sulphureous acid in this liquid state, may be prepared by pressing it through water in an apparatus nearly similar to that used for preparing oxygenerated muriatic acid. The cheapest method of obtaining it, is to decompose sulphuric acid by the mixture of some combustible capable of taking from it parts of its oxygen. In experimental chemistry, it is obtained by means of metallic substances with great purity, and particularly by mercury; but for bleaching, and where great economy is required, we would recommend the most common substances, and the following process.

Take chopped straw, or saw-dust, and introduce it into a mattress; pour over it sulphuric acid, applying at the same time heat, and there will be disengaged sulphureous acid gas (vapour of sulphur), which may be combined with water in the apparatus.

The pieces are rolled upon reels, and drawn through the sulphureous acid, by turning them, until the whiteness is sufficiently bright. They are then taken out, and drained on a bench covered with cloth, lest they should be strained by the decomposition of the wood and the sulphureous acid. They are next washed in river water, and Spanish white is employed, if necessary. This operation is performed by passing the pieces through a tub of clear water, in which eight pounds of Spanish white have been dissolved. To obtain a fine whiteness, the stuffs are twice sulphured. This process is completed in one immersion, and a reeling of two or three hours.

358. *To azure or blue* the cloth, you throw into the Spanish white liqour, a solution of one part of Prussian blue to 400 parts of water; shake the cloth in the liquid, and reel it rapidly.

Then by a slight washing with soap, to give softness and pliability to the stuffs, the operation is terminated. The final operations of *drying*, *stretching*, *pressing*, &c. have all been illustrated in what has been said of dyeing and bleaching linen, for the directions vary so little in both, that it would be but a repetition to detail here what the reader is already acquainted with.

To bleach Silk.

359. Silk has been explained as a semi-transparent matter, spun by a caterpillar, and formed of a substance contained in its body, which becomes hard in the air.

The filaments, prepared by the silk-worm, are rolled up in a ball, and in this state, it is covered with a yellow varnish that destroys its brilliancy and renders it tough. By chemical analysis, silk gives carbonate of ammonia and oil; boiling water produces no effect upon it; alkohol makes it experience no change but concentrated alkaline leys attack and dissolve it.

To give splendour to silk, it must be freed from its varnish. This covering is soluble in alkaline leys. Silk is usually scoured by soap, when it loses one-fourth of its weight. The matter disengaged has a fetid smell, and if the silk be not rinsed in plenty of water, putrid fermentation takes place. Even the least soap injures the whiteness of the silk. This is proved by the fact that the splendour of the Chinese silks is brighter than that of the European; and the Chinese employ no soap in their operations. A lightly alkaline ley will dissolve the varnish of the silk without using soap, and this has also been effected by the action of boiling water at a very high temperature.

360. The following method has been used very successfully in France.

Take a very weak solution of caustic soda, and fill with it the boiler of the apparatus for bleaching with steam. Charge the frames with skeins of raw silk, place them in the apparatus until it is full; then close the door, and make the solution boil. Having continued the ebullition for twelve hours, slacken the fire, and open the door of the apparatus. The

heat of the steam, which is always above 250 deg. will have freed the silk from the gum, and scoured it. Wash the skeins in warm water, wring them, place them again on the frame, in the apparatus, and make the whole boil a second time. Wash them now several times in water, and immerse them in soapy water to give them softness.

But the whiteness which silk acquires by these operations, is carried to a higher degree of splendour by exposing the material to the action of sulphureous acid gas, in a close chamber, or by immersing it in sulphureous acid, as we have explained for whitening wool.

To bleach Prints, and printed Books.

361. The new mode of bleaching has been applied to the whitening of books and prints that have been soiled by smoke and time, and therefore it will be proper that we here explain this process.

To whiten an engraving, immerse it in oxygenerated muriatic acid, letting the article remain in it a longer or shorter space of time, according to the strength of the liquid. To whiten the paper of a bound book, all the leaves must be moistened by the acid, and therefore care must be taken to open the book, and making the boards rest on the edge of the vessel so that the paper alone shall be dipped in the liquid: the leaves must be separated from each other, to be equally moistened on both sides.

In the same proportion as the liquor assumes a yellow tint, the paper becomes white. In about three hours, the book must be taken from the acid liquor, and the leaves plunged into pure water, with the same care and precaution as recommended in regard to the acid liquor, so that the water touch only the two surfaces of each leaf. The water must be renewed every hour, to extract the remaining acid, and dissipate the unpleasant smell.

By this process, there is however some danger that the pages may not be all equally white, either because the leaves have not been sufficiently separated, or because the liquid has had more action on the exterior margins than those near the binding. The best way is to destroy the binding, and each leaf will thereby receive an equal and perfect immersion, this second process is thus described by CHAPTAL.

" They begin," says he, " by unsewing the book, and separating it into leaves, which they place in cases formed in a leaden tub, with very thin slips of wood, or glass, so that the leaves, when laid flat, are separated from each other by intervals scarcely sensible. The acid is then poured in, making it fall on the sides of the tub, in order that the leaves may not be deranged by its motion. When the workman judges, by the whiteness of the paper, that it has been sufficiently acted upon by the acid, it is drawn off by a cock at the bottom of the tub, and its place is supplied by clear fresh water, which weakens and carries off the remains of the acid, as well as the strong smell. The leaves are then to be dried, and after being pressed, may be again bound up.

"The leaves may be placed also vertically in the tub; and this position seems to possess some advantage, as they will be less liable to be torn. With this view I constructed a wooden frame, which I adjusted to the proper height, according to the size of the leaves which I wished to whiten. This frame supported very thin slips of wood, leaving only the space of half a line between them. I placed two leaves in each of these intervals, and kept them fixed in their place by two small wooden wedges, which I pushed in between the slips. When the paper was whitened I lifted up the frame with leaves, and plunged them to remove the remains of the acid, as well as the smell; this process I prefer to the other.

"By this operation books are not only cleaned, but the paper acquires a degree of whiteness superior to what it possessed when first made. The use of this acid is attended also with the valuable advantage of destroying ink spots. This liquor has no action upon spots of oil or animal grease; but it has been long known that a weak solution of potash will effectually remove stains of that kind.

"When I had to repair prints so torn that they exhibited onlp scraps pasted upon other paper, I was afraid of losing these fragments in the liquid, because the paste became dissolved. In such cases I inclosed the prints in a cylindric glass vessel, which I inverted on the water in which I had put the mixture proper for extricating the oxygenated muriatic acid gas. This vapour, by filling the whole inside of the jar, acted upon the print; extracted the grease as well as ink spots; and the fragments remained pasted to the paper."

To prepare the Oxygenerated Muriatic Acid by an easy Method.

362. To oxygenerate the muriatic acid, dilute it, and mix it in a very strong glass with manganese, so that the mixture may not occupy the whole contents of the glass. Air bubbles are formed on the surface of the liquor; the empty space becomes filled with a greenish vapour; and at the end of some hours the

acid may be farther diluted with water, and then used. It will have an acid taste, because the whole has not been saturated with oxygen; but it will possess the qualities of the oxygenerated muriatic acid. This process may be adopted when there is not time to set up an apparatus for distilling, to procure the oxygenerated acid.

To bleach Paper.

363. The oxygenerated muriatic acid has also been applied to bleach paper, being more expeditious.

If we were *to bleach old printed papers, to be worked up again,* we must boil them for an instant in a solution of soda, rendered caustic by potash. Then steep them in soap-water, and then wash them, after which the whole may be reduced to a pulp by the paper-mill.

364. *To bleach old written papers to be worked up again,* we steep them in a cold solution of sulphuric acid in water, after which we wash them before they are taken to the mill. The acidulated water will be the more effectual if it be heated.

365. *To bleach printed papers without destroying the texture of the leaves,* we steep the leaves in a caustic solution of soda, and afterwards in one of soap. Then we arrange the sheets alternately between cloths, just as paper-makers dispose their sheets of paper when delivered from the form. The leaves must then be put in a press, and they will become whiter, unless they have been stained with printer's ink or size. If one operation should not completely effect the whitening of the leaves, you must repeat the process again and again.

366. *To bleach coloured rags to make white paper,* we macerate the rags—then put them into a solution of caustic alkali, and next into the oxygenerated muriatic acid, lastly, they are to be steeped in diluted sulphuric acid.

Note. These processes of bleaching have been classed under one general title, though the manufacture of paper has not been treated in conjunction with them.

SECTION II.

REMOVING STAINS.

To remove Ink Stains.

367. Apply to the stain muriatic acid diluted in six times its weight in water, and after a minute or two wash it off; the application should be repeated as often as may be found necessary. The vegetable acids equally effectual are attended with less risk.

A solution of the oxalic, citric (acid of lemons), or tartareous acids, in water, may be applied to the most delicate fabrics without danger or injury; and the same solutions will discharge writing, but not printing ink. They may be therefore employed in cleaning books defaced by writing on the margin. Lemon, and sorrel juice, will remove ink stains, though not so easily as the concrete acid of lemons or citric acid.

368. *To remove iron stains.* Ink stains, on the application of soap, are changed into iron stains. But the real iron stains are occasioned by the cloth coming in contact with iron, or its oxyde. Both may be removed by diluted muriatic acid, or by the acid of lemons.

When suffered to remain long on cloth, they are taken out with difficulty, because the iron, by repeated moistening with water, and exposure to the air, acquires such an addition of oxygen, as renders it insoluble in acids; yet these spots may be discharged, by applying first a solution of an alkaline sulphuret, which must be well washed from the cloth, and afterwards a liquid acid. The sulphuret, in this case, extracts part of the oxygen from the iron, and renders it soluble in diluted acids.

369. *To remove the stains of fruit and wine.* Prepare a watery solution of the oxygenerated muriatic acid, or oxygenerated muriate of potash or lime, to which a little sulphuric acid has been added. Steep the stained spot in one of these solutions till it is discharged; the solution can only be applied to white goods, for the uncombined oxygenerated acid discharges printed and dyed colours.

The oxygenerate acid, is easily applied by persons who have not the apparatus for saturating water with the gas, thus:—Put a table-spoonful of muriatic acid (*spirit of salt*) into a tea-cup, and add to it about a tea-spoonful of powdered manganese; set this cup in a larger one filled with hot water; moisten the stained spot with water, expose it to the fumes which arise from the tea-cup, and if the exposure be continued a sufficient length of time, the stain will disappear entirely.

370. *To remove spots of grease from cloth.* Spots of grease may be removed by a diluted solution of potash, which must be cautiously applied to prevent injury to the cloth. Stains of white wax, from wax candles dropping upon the cloths, are removable by spirits of turpentine, or sulphuric ether, which will also take out the marks of white paint.

371. *To take spots of grease out of books, prints, or paper.* Warm the paper gently that is stained with grease, wax, oil, or any other fat body, and take out as much of the stain as possible by means of blotting paper; then dip a small brush in essential *oil of turpentine*, heated almost to boiling (when cold it acts weakly), and draw it gently over both sides of the paper, which must be carefully kept warm. Repeat this operation as often as the spot imbibed by the paper or its thickness, may render necessary.

When the greasy substance has been removed, the paper may be restored to its former whiteness by the following method. Dip another brush in highly rectified spirit of wine, and draw it over the place which was stained, and particularly round the edges, to remove the border that would still present a stain. By employing these means with caution, the spot will disappear and the paper will resume its original whiteness. Should the process be employed on a part written with common ink, or printed with printer's ink, it will experience no alteration whatever.

SECTION III.

OF STAINING WOOD.

372. *To stain wood yellow:* Any white wood may be stained yellow, by the following process. Brush the wood over several times with the tincture of turmeric root. This tincture is made of one ounce of turmeric powder mixed in a pint of water, Dragon's blood will give the colour a reddish hue.

French berries boiled make a cheaper, but less strong and bright yellow.

Aqua fortis will stain yellow, but sometimes the experiment fails, and you get a brown for a yellow. If it is too strong, the colour is blackish.

373. *To stain wood red.* To procure a bright *red stain* for wood, make a strong infusion of Brazil wood in stale urine, or water impregnated with pearl-ashes, in the proportion of an ounce to a gallon. To a gallon of either of these, the proportion of Brazil wood must be a pound, which being put to them, the whole must stand together for two or three days, often stirring the mixture. With this infusion strained, and made boiling hot, brush over the wood to be stained till it appear strongly coloured; and, while wet brush it over with alum water in the proportion of two ounces of alum to a quart of water.

For a less bright red, dissolve an ounce of *dragon's blood* in a pint of spirits of wine, and brush over the wood with the tincture till the stain appear as strong as is desired; this however is rather lacquering than staining.

For a pink or rose red, add to a gallon of the above infusion of Brazil wood two additional ounces of the pearl-ashes, and use it as was before directed: in this case also brush the wood over with the alum water. By increasing the proportion of pearl-ashes, the red may be rendered yet paler; it is proper, however, when more than this quantity is added, to make the alum water stronger.

374. *To stain wood blue.* Wood may be stained blue, by copper or indigo.

The method of staining blue with copper is this: make a solution of copper in aqua fortis, brush it while hot several times over the wood; then make a solution of pearl-ashes in the proportion of two ounces to a pint of water; and brush it hot over the wood stained with the solution of copper, till it be of a perfectly blue colour.

375. *To stain wood green.* Dissolve verdigris in vinegar, or crystals of verdigris in water, and with the hot solution brush over the wood till it be stained as deep as you choose.

376. *To stain wood purple.* Brush the wood several times with a strong decoction of logwood and Brazil, made in the proportion of one pound of the log-wood, and a quarter of a pound of the Brazil, to a gallon of water, and boiled for more than hour. When the wood has been brushed over till there be a sufficient body of colour, let it dry, and then be slightly passed over by a solution of one drachm of pearl-ashes in a quart of water. This solution must be carefully used, as it will gradually change the colour from a brown red, which it will be originally found to be, to a dark blue purple, and therefore its effect must be restrained to the due point for producing the colour desired.

377. *To stain wood a mahogany colour.* The substances used for staining this colour are madder, Brazil wood, and logwood; each of which produces a reddish brown stain, and therefore they must be mixed together in such proportions as will produce the tint required.

378. *To stain wood black.* Put a quarter of a pound of powdered galls to two quarts of water, set them

in the sunshine, or any other gentle heat, for three or four days, brush over the wood several times with a hot decoction of logwood, and then three or four times with the infusion of galls, and it will be of a beautiful black. It may be polished with a hard brush and shoemaker's black wax to look like ebony.

CHAPTER XI.

SCIENTIFIC EXPERIMENTS.

EXPERIMENT I.

To make Phosphorus.

379. Phosphorus may be prepared from urine by the following method.

Dissolve as much lead in the nitric acid as it will act upon, the solution will be nitrate of lead; pour this into a quantity of urine, and a precipitate will be formed. When no more precipitate falls by the addition of the solution, let the whole stand undisturbed till it has all subsided, then pour off the clear fluid and make this precipitate into a paste with charcoal finely pounded, dry it gradually in an earthern pan. Then put the mass into an iron or earthern retort, and distil it. The phosphorus will come over, and may be collected under water.

EXPERIMENT II.

Canton's Phosphorus.

380. Calcine some oyster shells, by keeping them in a good fire for about an hour. Select the purest and whitest parts of the calcined shells, and pound and sift them. To three parts of this lime, add one of flowers of sulphur; mix them together, put them well pressed into a crucible, which, place in a good

fire, where it must be kept red hot for at least an hour; it may then be taken out to cool. When cold, break the mass to pieces, and select out of it the brightest part, which will shine in the dark.

Experiment. A beautiful representation of the telescopic appearance of one of the planets, may be made by means of this. Cut out in paper the shape of the planet, such as a half moon, Saturn, and his ring, &c. and cover it over with strong gum water; then strew some of this phosphorus, finely powdered, over the surface. When you want to exhibit it in the dark, you must previously expose it for a few minutes to the light of an Argand's lamp; or, what is better, make the flash from the discharge of a large electrical jar, or battery pass over its surface, and it immediately becomes luminous, and exhibits a very exact resemblance of the planet.

EXPERIMENT III.

Phosphoric Oil.

381. Put one part of phosphorus into six of olive-oil, digest them over a sand heat, and the phosphorus will dissolve. It must be kept well corked.

Experiment. This oil has the property of being luminous in the dark, yet it has not sufficient heat to burn any thing. Shut the eyes, rub it on the face and hands, the appearance is most hideously frightful; all the parts with which it has been rubbed, appearing covered with a luminous lambent flame of a bluish colour, and the mouth and eyes appear in it as black spots. There is no danger attending this experiment. The light is sufficient to shew the hour of the night on a watch, by holding it close to the bottle when it is unstopped.

EXPERIMENT IV.

Phosphorated Lime.

382. Put a few grains of phosphorus into the bottom of a Florence flask, fill it up with quick-lime, and place it over a lamp till the phosphorus has sublimed, and is thoroughly mixed with the lime. If any of this lime be thrown out in the dark, it has the appearance of a shower of fire, but cannot

burn any thing, as the quantity of phosphorus is too small to produce any sensible heat.

EXPERIMENT V.

Phosphoric Fire Bottle.

383. Take a small phial, put a bit of phosphorus as large as a pea into it, and fill up the bottle with lime. Fix an iron shovel, with common sand, and put it over the fire. Set the phial in this sand, having loosely stopped it with a cork. Stir about the ingredients with a wire to mix them together, taking care that the phosphorus does not catch fire by too great an access of air. Keep the bottle in the sand till the phosphorus is thoroughly incorporated with the lime, when it will be of a reddish yellow.

This bottle is extremely convenient for procuring an instantaneous light in the dark, nothing more being necessary than to uncork the bottle, and introduce a brimstone match, stirring it about a little, by which it will catch fire and light.

The bottle must be always kept corked, and opened as seldom as possible.

A more durable kind may be made by uniting together one part of sulphur with eight of phosphorus. When this is used, a match is introduced into it, and then rubbed upon a bit of cork.

EXPERIMENT VI.

Phosphuret of Lime.

384. Put half an ounce of phosphorus, cut into small bits, into a glass tube about a foot long, and half an inch in diameter, closed at one end. Fill up with quick-lime grossly powdered, and stop the mouth of the tube loosely. Heat that part of the tube which contains the lime, over a chafing dish, till it be red hot; then apply the heat of a lamp to the part containing the phosphorus, which will sublime, and mix with the lime. When cooled, the mixture will be a reddish mass.

If phosphuret of lime be dropped into water, air bubbles will be disengaged, which, on bursting at the top, will inflame with small explosions. They consist of phosphorated hydrogen gas.

EXPERIMENT VII.

Fulminating Powder.

385. Triturate in a warm mortar three parts by weight, of nitre, two of mild vegetable alkali (carbonate of potash,) and one of flowers of sulphur. A few grains of this laid upon a knife, and held over the candle, first fuses, and then explodes with a loud report. A drachm of it put into a shovel, and held over the fire, makes a noise as loud as a cannon, and indents the shovel as if it had received a violent blow.

EXPERIMENT VIII.

Fulminating Mercury.

386. Dissolve 100 grains of mercury with heat, in a measured ounce and a half of nitric acid. This solution poured cold upon two measured ounces of alkohol, previously introduced into any convenient glass vessel, a moderate heat is to be applied till effervescence is excited. A white fume then undulates on the surface of the liquor, and the powder will be gradually precipitated on the cessation of action. The precipitate must be immediately collected on a filtre, well washed with distilled water, and cautiously dried in a heat not exceeding that of a water bath. The immediate washing of the powder is material, as it is liable to the re-action of the nitric acid; and while any of the acid adheres to it, it is subject to the action of light. From 100 grains of mercury, about 120 or 130 of the powder are obtained.

This powder, struck on an anvil with a hammer, explodes with a stunning disagreeable report; and with such force as to indent both the hammer and the anvil. Three or four grains are as much as ought to be used for such experiments.

EXPERIMENT IX.

The Phosphorescence of Minerals.

387. In making these experiments, says Dr. Brewster, I never reduced the body to powder, but always placed a fragment of it upon a thick mass of hot iron, carried into a dark room. When the phosphorescence was not readily perceived by this method, I took a pistol barrel, and having shut up the touch-hole, I introduced the mineral into the breach, and placed the bottom of the barrel in the fire. Before a red heat was produced, the phosphorescence was distinctly seen by looking into the barrel, which I sometimes did through a plate of glass, to keep the heated air from the eye, and sometimes through a small telescope, adjusted to distinct vision at the bottom of the barrel. At other times the mineral was not introduced into the barrel till it was taken out of the fire, and till the red heat had entirely disappeared.

In this way, I obtained the following results.

Table of Phosphorescent Minerals.

	Names of the Minerals.	*Colour of the Minerals.*	*Colour and Intensity of their Light.*
	Fluor spar	Pink	Green
	———	Purple	Bluish
	———	Bluish-white	Blue
	Compact fluor	Yellowish	Fine Green
5	Sandy fluor	White	White sparks
	Calcareous spar	Yellow	Yellow
	———	Transparent	Yellowish
	Limestone from the North of Ireland		Yellowish-red
	Phosphate of lime	Pink	Yellow
10	Arragonite	Dirty white	Reddish-yellow
	Carbonate of barytes	Whitish	Pale white
	Harmotome	Colourless	Reddish-yellow

	Names of the Minerals.	*Colour of the Minerals.*	*Colour and Intensity of their Light.*
	Dipyre	White	Specks of light
	Grammatite from Glentilt		Yellow
15	Grammatite from Cornwall		Bluish
	Topaz, Aberdeenshire	Blue	Bluish
	—— Brazilian	Yellow	Faint yellowish
	—— New Holland	White	Bluish
	Rubellite	Reddish	Scarlet
20	Sulphate of lime	Yellowish	Faint light
	—— barytes	Yellow	Pale light
	——	Slate colour	Pale light
	Sulphate of strontites	Bluish	A fragment shone pretty bright
	—— lead	Transparent	Faint and by fits
25	Anhydrite	Reddish	Faint light
	Sodalite	Dark green	Pretty bright
	Bitter spar	Yellowish	Faint white
	Red silver ore	Red	Pretty bright, but fitting
	Barystrontianite	White	Faint
30	Arseniate of lead	Yellowish	Bright white
	Sphere	Yellow	Bright white
	Tremolite	Whitish	Reddish-yellow
	Mica	Greenish	Whitish
	—— from Waygatz	Black	White specks
35	——	Brown	Pretty bright
	Titanium sand	Black	Feeble specks
	Hornstone	Grey	Yellowish
	Table spar, Dognatska	Whitish	Yellowish
	Lapis lazuli	Blue	Faint
40	Spodumene	Greenish	Faint
	Titanite	Reddish	Extremely faint
	Kyanite	Yellowish white	Bluish
	Calamine	Brown	Faint
	Augite	Green	Pretty bright
45	Petalite	Reddish tinge	Blue and very bright
	Asbestos rigid	——	Pretty bright
	Datholite	Transparent	Bright
	Corundum	Brown	Bright
	Anatase	Dark	Reddish-yellow
50	Tungstate of lime	Yellowish white	Brilliant like a burning coal

Names of the Minerals.	*Colour of the Minerals.*	*Colour and Intensity of their Light.*
Quartz	The Phosphorescence of these nine minerals was observed in the pistol barrel	Very faint
Amethyst		Faint
Obsidian		Pretty bright, dirty blue
Mesotype from Auvergne		Very faint
55 Glassy actynolite		Little specks
Ruby silver		Rather bright
Muriate of silver		Blue
Carbonate of copper		Pale blue, and pretty bright
Green Telesie		

EXPERIMENT X.

Arbor Dianæ, or Tree of Diana.

388. Half an ounce of fine silver, and two drachms of mercury dissolved separately in a quantity of aqua fortis are then mixed together, and poured into a pint of common water, and stirred about, that the whole may be well mixed.

This preparation is kept in a bottle well corked. In a glass globe, or other vessel, put the amalgam of silver with mercury, the quantity of a small nut, pour three or four ounces of the above liquor over it, and some hours after, there will arise from the globular amalgam small branches, which by increasing, will form a beautiful silver shrub.

EXPERIMENT XI.

Silver Tree on Glass.

389. Put a few drops of the solution of silver in aqua fortis on a piece of glass, form a bit of copper or brass wire to represent a tree with its branches, but flat, so as to lie upon the glass, lay it in the liquid, and let it remain for an hour or two. A beautiful vegetation will be perceived all round the wire, which will nearly be covered by it. This may be preserved by washing it very carefully with water, and putting another glass over it.

EXPERIMENT XII.

Lead Tree.

390. Dissolve an ounce of sugar of lead in a quart of clear water, put it into a glass decanter or globe, then suspend in the solution, near the top, a small piece of zinc of an irregular shape. Let it stand undisturbed for a day, and it will begin to shoot out into leaves, and apparently to vegetate. If left undisturbed for a few days, it becomes extremely beautiful; but it must be moved with great caution.

It may appear to those unacquainted with chemistry, that the piece of zinc actually puts out leaves; but this is a mistake, for if the zinc be examined, it will be found nearly unaltered. This phenomenon is owing to the zinc having a greater attraction for oxygen than the lead has, consequently, it takes it from the oxyde of lead, which re-appears in its metallic state.

EXPERIMENT XIII.

Arbor Martis, or the Tree of Mars.

391. Dissolve iron filings in aqua fortis moderately concentrated, till the acid is saturated; then add to it gradually a solution of fixed alkali, (oil of tartar per deliquium.) A strong effervescence will ensue, and the iron, instead of falling to the bottom of the vessel, will afterwards rise, and cover the sides, forming a multitude of ramifications heaped one upon the other, which will pass over the edge of the vessel, and extend themselves on the outside with all the appearance of a plant.

EXPERIMENT XIV.

Iron changed into Copper

392. Dissolve some blue vitriol (sulphate of copper) in water, dip into the solution a piece of bright iron or steel; and in a few seconds it may be taken out, when it will be apparently turned to copper.

This is a deception; the iron is not changed into copper; it is only encrusted with that metal, as may be easily seen by removing the copper by a file. The iron having a stronger attraction for sulphuric acid than copper, it takes the acid from the latter, which is consequently precipitated. This process is used for obtaining the copper from waters near mines that contain a great quantity of that metal. Iron plates are put into them, which become incrusted with copper, which is then scraped off.

EXPERIMENT XV.

To prove the destructive effects of inhaling Carbonic Acid Gas.

393. Fatal accidents frequently occur to persons who venture into wells or deep pits which have been long shut up. Similar effects are produced to workmen who incautiously descend into large vats in breweries, or into cellars where malt liquors have been, or are fermenting, and more than once have imprudent men in holding their noses over the bung hole of a porter cask, fallen backwards and instantly expired.

Accidents of a similar nature occur to those who have accidentally confined themselves in a close room where a pan of charcoal has been left burning; and the customs of warming beds with red-hot charcoal, or of using charcoal stoves in manufactories, and in wine cellars to *ripen* or *bring forward* the wine, cannot be too much reprehended. In 1816, a young man in Paris, disgusted with life, committed suicide in the following manner. He carefully shut the door and windows, and then lighting a charcoal fire in the middle of the room, retired to bed. He was found dead next morning!

The cause of all these fatalities, is the inhaling of carbonic acid gas, which in the combustion of charcoal, is formed by an union of oxygen of the atmosphere with the charcoal or carbon in a diluted state. The mode of its formation in wells, caverns, and pits, has not been duly ascertained. As this gas is heavier than common air, its presence may easily be ascertained by trying if a lighted candle will burn in it.

This precaution is always necessary before descending into an old well or mine; it may be done, by tying an open lantern to a rope, and allowing it to descend gradually.

It was from the abundant generation of this noxious gas, that the Lake Avernus was so destructive to animal life, so that birds flying over it, near the surface, dropped down dead.

The Grotto del Cave, or the Cavern of Dogs in Italy, is another remarkable reservoir of this destructive gas: the following description of it is taken from Addison's Travels.

"The grotto is famous for the poisonous steams which float within a foot of its surface. The sides of the grotto are marked with green as high as the malignity of the vapour reaches. The common experiments are as follow: a dog that has his nose held in the vapour loses all signs of life in a very little time, but if carried into the open air, or thrown into a neighbouring lake, he immediately recovers, if he is not quite dead. A torch, snuff and all, goes out in a moment when dipped into the vapour. A pistol cannot take fire in it. I split a reed, and laid in the channel of it a train of gunpowder, so that one end of the reed was above the vapour, and the other at the bottom of it; and I found, that though the steam was strong enough to hinder a pistol from taking fire in it, and to quench a lighted torch, that it could not interrupt the train of fire, when it had once begun flashing, nor hinder it from running to the end. This experiment I repeated twice or thrice, to see if I could quite dissipate the vapour, which I did in so great a measure that one might easily let off a pistol in it. I observed how long a dog was in expiring the first time, and after his recovery I found no sensible difference. A viper bore nine minutes the first time we put it in, and ten the second. When we brought it out after the first trial, it took such a vast quantity of air into its lungs, that it swelled almost twice as big as before; and it was, perhaps, on this stock of air, that it lived a minute longer the second time."

EXPERIMENT XVI.

Phenomena of the natural combination of Hydrogen Gas and Carburetted Hydrogen Gas.

394. To hydrogen gas and its combinations are owing many natural phenomena. The meteors called *falling stars* consist of this gas in a state of combustion by electricity. *Ignus fatui* owe their origin to an extrication of this gas from swamps, church-yards, and other places where animal and vegetable matters have been deposited. Phosphorus in minute combination is always present with the hydrogen gas to form the *Jack o'lanthern.* The

aurora borealis no doubt is caused by the combustion of this gas in the upper regions of the atmosphere.

There are various places in the earth where hydrogen gas produced by nature far below the surface of the ground, issues out and is inflamed. An experiment has been frequently performed, which will sufficiently account for this formation. A quantity of iron-filings and sulphur mixed together with some water, has been buried under ground, and, after some hours, flames have burst forth. The oxygen of the water has been found to unite with the iron with very great heat, and the hydrogen being separated in the form of gas, on coming in contact with the air of the atmosphere, has been inflamed. Stores of such substances in the bowels of the earth, when water by any means has found its way, may produce the same effect, and hence the gas will be formed, which will issue forth, and still retaining its heat, will be inflamed. The ancient Magi of Persia availed themselves of such a natural production of fire to impress the worship of that element on the minds of their votaries. The Chimæra, painted in fanciful colours by the ancients, and by many supposed to be a mere creature of their fancy, was, in reality, a flame of this sort which burst from a mountain of Lycia, in Asia Minor. It has lately been visited, and easily explains what the poets have said of it.

Flames of this kind are not always constant. On the side of a hill, in one of the Turkish islands, the flames burst forth, and serve as a light-house to warn ships of their danger. On one occasion, when there was an intermission of this flame, we are told, by Dr. Clarke, a Turkish frigate was unfortunately wrecked. The captain insisted on the poor inhabitants making him a recompense for the loss of his ship. It was in vain they argued that the light was not under their controul: his reply was, "ye cannot deny, that if your island had not been here, my vessel would not have been wrecked upon it."

One of the most remarkable volcanoes of this description in Europe is near Pietra Mala, on the summit of the Appennines, near the road which leads from Bologna to Florence. In October, 1817, the flames issued from the ground in two places, of which one was five paces in length and more than one in breadth; the other flame was only one pace in length. The flames rose about a foot and a half. The whole space of ground burnt over was ten paces long and five broad. Where the flame was abundant, it was of a fine white colour, but where less violent it was blue. The hand was not burnt by drawing it along the ground from which the flame issued, but heat was felt in passing on the lee-side of it. By raking violently with a stick over the ground whence the smaller flame issued, it was extinguished; and on being touched by a lighted paper, immediately blazed out. After a long-continued heavy rain, it is remarked by the neighbouring peasantry, that the flames are much more extensive and violent, which is a proof of the origin of the gas, and of the mineral bodies producing it, being far down in the bowels of the earth. At some distance from the volcano is a well, from which gas issues, which will inflame on a light being held to it. The gas there, in forcing its way to the surface, is cooled in its passage through the water, and, therefore, does not inflame of itself. It is, perhaps, scarcely necessary to add, that volcanoes of this sort are totally different in their nature from the terrific internal fires of Vesuvius and Etna.

EXPERIMENT XVII.

Precipitate of Cassius.

395. This beautiful purple colour so useful to enamellers and glass stainers, is made as follows:

Dissolve some gold in aqua regia (nitro muriatic acid,) and also dissolve some pure tin in diluted aqua regia, and pour it into the solution of gold. A purple powder will be precipitated, which collected, is washed in distilled water.

EXPERIMENT XVIII.

To Silver Ivory.

396. Take a slip of ivory, which immerse in a weak solution of nitrate of silver, till the ivory has acquired a bright yellow colour; then take it out of the solution, and immerse it in a tumbler of pure water, and expose it in the water, to the rays of a very bright sun. After the ivory has been exposed to the sun's rays for some hours, it becomes black; but on rubbing it a little, the black surface is changed into one of silver. Although this coating of silver is extremely thin, yet if the ivory be well impregnated with the nitrate of silver, the solution will pe-

netrate to a considerable depth; and as fast as the silver wears off from the surface of the ivory, the nitrate below being exposed to the light, is converted into silver, and the ivory retains its metallic appearance.

EXPERIMENT XIX.

To cover Ribbons with Gold.

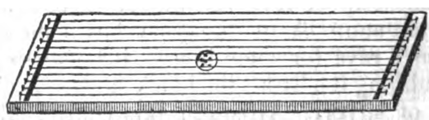
397. Let ether stand over phosphorus for some weeks, and some of the phosphorus will be dissolved. Dissolve also some gold in aqua regia (nitro muriatic acid.) Dip the ribbon, first, into the nitro muriatic solution, then into the phosphorated ether, and it will be covered with a firm coating of gold.

The same effect is produced by exposing the ribbon, after having dipped it into the solution of gold, to a current of phosphorated hydrogen gas for some days.

EXPERIMENT XX.

To make an Æolian Lyre.

398. The time of the invention of this musical instrument is not precisely known; but it was mentioned by father Kircher, more than 140 years ago. Its construction is very simple; the instrument being merely a long narrow box of thin deal, according to the annexed figure. The usual length of the *Æolian harp*, or *lyre* is two feet and a half; its breadth five or six inches; and its depth, from one and three quarters, to two inches. It has a circle pierced with small holes, on its upper side: this circle is generally from one and a half to two inches in diameter.



At each end of the upper side, are placed a small notched piece of wood like the bridge of a violin. Over these bridges, and fixed by screw-pins, at each end of the instrument are stretched, ten, twelve or fifteen strings of fine cat-gut, which may be tightened or relaxed by turning the pins by means of a key. The strings being tightened to the proper pitch, the instrument is to be placed under the lower sash of a window, so that a current of air may be enabled to pass over the strings. The instrument will be preserved in this situation by the weight of the windows. As the air enters at the window with different degrees of velocity, the strings will be differently affected, that is, different sounds or notes will be produced. Sometimes these notes will be in perfect accordance with each other: and at others the current of air, will bring out all the tones in full concert. In many cases, by mere accident, parts of well-known tunes will be played. When the current of wind becomes calmer, the sounds will die away in the softest murmurs; and all at once, a fresh gale springing up, the notes will gradually acquire such a degree of strength, harmony and loudness as to cause the utmost surprise; but this is speedily relieved by a rapid succession of sinking and swelling notes. The Æolian Lyre is usually placed under the window of a bed-chamber; and certainly there is no mode of serenading, more calculated to inspire delight, soothe melancholy, and minister to the passion of love. In short it is peculiarly adapted to cause a complete abstraction of thought from all sublunary concerns.

EXPERIMENT XXI.

Aurum Musivum.

399. Aurum musivum used by japanners, and for varnished works, as snuff boxes, coaches, &c. has all the beautiful appearance of gold in powder.

Amalgamate twelve parts of the purest tin with three parts of mercury; the amalgam is then triturated in a stone mortar with seven parts of flowers of sulphur and three parts of sal ammoniac. The mixture is next put into a mattras, and the whole exposed to a gentle sand head, until no more white fumes arise. When, upon this, the heat is somewhat raised, cinnabar sublimes, together with some oxygenated muriate of tin: while, at the same time, the remaining tin and sulphur unite forming the aurum musivum, exhibiting a golden yellow and flaky or scaley matter, of a metallic lustre.

The main point in this process is the proper regulation of the fire: when too strong, the operation does not succeed; and instead of aurum musivum, common sulphuret of tin is obtained.

EXPERIMENT XXII.

Artificial Volcanoes.

400. Mix equal parts of pounded sulphur and iron-filings, and having formed the whole into a paste with water, bury a quantity of it, forty or fifty pounds, for example, at about the depth of a foot below the surface of the earth. In ten or twelve hours afterwards, if the weather be warm, the earth will swell up and burst, and flames will issue out, which will enlarge the aperture, scattering around a yellow and blackish dust.

It is not impossible, that what is here seen in miniature, takes place on a grand scale in volcanos; as it is well known that they always furnish abundance of sulphur, and also metallic substances.

EXPERIMENT XXIII.

Chinese Bells.

401. Nankin, in China, has been long very famous for the immense size of its bells; but their enormous weights brought down the tower in which they were suspended. They fell with a mighty crash, and the bells have ever since lain on the ground.

One of these bells is nearly twelve feet in height; its diameter is seven and a half; and its circumference twenty-three. Its figure is almost cylindrical, except in the middle, where it bulges out considerably. The thickness of the metal of this bell, at the edges, is seven inches; and from its dimensions, its total weight is supposed to be 50,000 pounds, which is more than double that of the great bell of Erfurt, which was deemed by father Kircher to be the greatest bell in the world. The bells of Nankin were cast by order of the first emperor of the present dynasty, about 300 years ago. Each of them is named: one is called *tchou*, or the hanger; another *ceke*, or the eater; a third, *choui*, or the sleeper; and a fourth *fi*, or the will.

Father le Compte says, that there are seven bells in Pekin, cast in the reign of Youlo; each of which, weighs 120,000 pounds. But the sound of all these is far from being loud, in proportion to their size, as they are struck by a *wooden* instead of an iron clapper.

EXPERIMENT XXIV.

Artificial Lightning.

402. Provide a tin tube larger on one side than the other, and in which there are several holes. Fill this tube with resin, in powder, and when shook over the flame of a torch, it will produce a sudden corruscation, strongly resembling a flash of lightning. This is the manner in which theatrical lightning is produced; it is not the flame itself that is seen, but its reflection only, as happens for the most part in Nature.

In this manner also the flambeaux of the furies on the stage are constructed, except that, at the end of each, there is a match dipped in spirits of wine; by means of which it is only necessary to shake the flambeaux, and they will produce a sudden and very considerable flame.

EXPERIMENT XXV.

Asthma cured by Galvanism.

403. Dr. Wilson Phillip conceiving that *galvanism* and the *nervous energy* were identical, determined on applying the former as a remedy where the latter was deficient. The following cases will illustrate the success of his experiment.

Asthma appears to be entirely a disease of the nerves, the lungs, even in obstinate chronic cases, not being in the least injured; he applied galvanism, and found it of material benefit in eighteen cases in the Worcester Infirmary, and in four cases of private practice. In every one of them immediate benefit was experienced; in most of them it afforded greater relief than any preceding medicine tried, and in two of the cases it produced a complete cure. The method was to apply a piece of tin-foil to the nape of the neck, and another to the pit of the stomach. The wires from the two ends of the galvanic battery were connected with these, and the galvanism was continued for about ten minutes. At first it was very weak, being confined to three or four pairs of plates of four inches square, excited by water mixed with one-twentieth of its weight of muriatic acid; but was gradually increased till it consisted of twenty or twenty-five pairs of plates, by removing one of the wires along the battery. The galvanism was applied once in twenty-four hours; but in two cases, in which it produced permanently beneficial effects, it was applied twice in twenty-four hours.

EXPERIMENT XXVI.

Glass cut by Heat.

404. Take a common wine-glass or any vessel you want cut, and having heated a poker in the fire till it is almost red hot, apply it to the part where you wish the crack to begin; having held it upon the part for about a minute, remove the poker, wet the place; and the glass will immediately crack. Having now begun the crack, you may lead it in any direction, by merely drawing the hot poker in the direction you want. This is extremely useful in many chemical experiments, where you are in want of proper apparatus. Glass tubes may be easily cut with a file.

EXPERIMENT XXVII.

Nitrate of Silver Pictures.

405. Light has a powerful effect upon many of the metallic oxydes, causing them to turn black; and we avail ourselves of this property for copying paintings on glass, and making profiles of figures by means of nitrate of silver.

Cover white paper, or leather, with a solution of nitrate of silver, place it behind a painting on glass, exposed to the rays of the sun, which coming through will blacken the paper; but the shades will be more or less deep, in proportion to the quantities of light transmitted through the different parts of the glass. Where the glass is transparent, and all the light comes through, the paper will be made quite black; where the glass is opaque, and does not transmit any light, the paper will be quite white; and there will be degrees of depth of the shadow of every variety between these.

This picture is not sensibly affected by the light of candles or lamps; but the day-light soon destroys it, causing all the paper to become black; nor have any means hitherto tried for preventing this, been successful.

Besides the application of this property of nitrate of silver to copying the light and shadow of paintings on glass, delineations may be made of all such objects as are partly opaque and partly transparent. The fibres of leaves, and the wings of insects, may be accurately represented by only making the solar rays pass through them, upon prepared leather or paper.

Sir H. Davy found, that the images of small objects produced by means of the solar microscope, may be copied without difficulty on prepared paper. The best proportion was one part of nitrate to about ten of water. This is sufficient to enable the paper to become tinged, without hurting its texture.

EXPERIMENT XXVIII.

To make Artificial Fire-works.

406. Artificial fire-works are of two kinds, those made of gunpowder, nitre, and other inflammable substances and filings of the metals, camphor, &c. and those produced by hydrogen or inflammable air.

Those made with gunpowder are well known, and are called rockets, fire-wheels, tourbillons, &c.

Of these, the most usual are rockets; which are made by ramming into strong cylindrical paper cases put into wooden moulds, like small hollow columns, powdered gunpowder, or the ingredients of which it is composed, viz. saltpetre, sulphur, and charcoal, very dry.

To represent a fiery rain falling from the rocket, mix among your charge a composition of powdered glass, filings of iron, and saw-dust: this shower is called the peacock's tail, on account of the various colours exhibited. Camphor mixed with the charge, produces white or pale fire; resin a reddish colour, sulphur a blue, sal ammoniac a green, antimony a reddish yellow, ivory shavings a silvery white, pitch a deep or dark coloured fire, and steel filings, beautiful coruscations and sparks.

Sticks are fastened to the rockets, by which they are projected into the air, after they have been lighted: the charge burning with great intensity at one end, acts upon the air, which, in its turn, re-acts upon the rocket, and causes it to ascend, on the same principle as a boat is put off by a man in it, who pushes against the shore with a boat-hook.

Fire-works by means of *inflammable air* are the most elegant; and being free from smell or smoke, may be exhibited in a room without any disagreeable effect.

EXPERIMENT XXIX.

The Oracular Head.

407. Place a bust on a pedestal in the corner of a room, and let two tubes, one from the mouth and the other from the ear pass through the pedestal and the floor, to an under apartment. There may be wires likewise attached to the eyes and jaw which must pass through the floor, to give the bust, apparent animation.

A person being placed in the under room, must apply his ear to the tube proceeding from the ear of the bust, at a given signal: he will thus be enabled to hear any question that may be asked by one of the company present. To reply, he must, (at the same time that he pulls the wires) place his mouth to the tube attached to the mouth of the bust, and make any answer, most suitable to the question asked. This deception is admirable, as, at the same time that the voice of the bust is heard, the motion of the eyes, &c. give a natural expression to the countenance, There is little doubt, but this method was the same that was practised by the ancient oracles to deceive those who were eager to know their future fortune.

EXPERIMENT XXX.

The Solar Organ.

408. In a large case, such as is used for dials and spring clocks, the front of which, or at least the lower part of it, must be of glass, covered on the inside with gauze, let there be placed a barrel organ, which, when wound up, is prevented from playing by a catch that takes a toothed wheel at the end of he barrel. To one end of this catch there must be

joined a wire, at the end of which there is a flat circle of cork, of the same dimensions with the inside of a glass tube, in which it is to rise and fall. This tube must communicate with a reservoir that goes across the front part of the bottom of the case, which is to be filled with spirts, such as is used in Thermometers, but not coloured; that it may be the better concealed by the gauze.

This case being placed in the sun, the spirits will be rarefied by the heat; and rising in the tube, will lift up the catch or trigger, and set the organ in play; which it will continue to do as long as it is kept in the sun; for the spirits cannot run out of the tube, that part of the catch to which the circle is fixed being prevented from rising beyond a certain point by a check placed over it.

When the machine is placed against the side of a room on which the sun shines strong, it may constantly remain in the same place, if you enclose it in a second case made of thick wood, and placed at a little distance from the other. When you want it to perform, it will be only necessary to throw open the door of the outer case, and expose it to the sun. But if the machine be moveable, it will perform in all seasons by being placed before the fire; and in the winter it will more readily stop when removed into a cold place.

EXPERIMENT XXIX.

Artificial Grottos.

409. The idea of artificial grottos is usually wrongly conceived. Those who construct them imagine that they are imitating Nature, while every thing they do is directly the reverse. Who ever saw a natural grotto or cavern, covered in the inside with beautiful shells stuck all over it, intermixed with pieces of coral, looking-glass, and every species of shewy ornament? And those who aim at making a more sober species of grotto, by introducing only rough masses of stone to imitate natural rocks, and covering the whole with moss, weeds, &c. always fail in their attempts to imitate Nature.

Another idea is, that with regard to artificial grottos, they need not represent *natural caverns*, but the supposed productions of enchantment or magic. Incongruities may here disappear, and imagination and taste riot in the display of magical power; every species of natural or artificial productions may now be combined together, and every thing introduced that may excite astonishment and prolong surprise. There is no necessity however for imitating the appearance of natural grottos, where regularity and irregularity are alike licensed. The sciences of architecture and mechanics may thus lend their aid in the construction of places, where nature is not the object of imitation, but where every thing is employed to dazzle the fancy.

Shell work, corals, statues, fountains, streams of water, paintings, curious musical pieces of mechanism; in short, every thing extraordinary, may be introduced with great success; and in this art there is an ample field for the display of taste.

In the external of a grotto the least attempt at ornament should be made. If it resemble some hermitage constructed of roots of trees, or some similar kind of structure; so far, so good; but no attempt should ever be made here to imitate a natural cavern, except, indeed, the situation should be peculiarly happy for this purpose.

A cement for fixing large shell-work and stones is thus prepared: melt together resin, pitch, and bees-wax, and add to it powdered marble or free-stone, and a little sulphur. Any of the finer cements mentioned under the article *cements*, may be used for delicate purposes.

The taste of those who spend their time in making small pieces of shell-work to put into frames, must be sadly perverted; pity it is to see so much ingenuity and patience misapplied; for the thing produced can never affect the mind with any refined sensation; it is a childish toy, the construction of which is an unfit employment for the leisure of one possessed of powers capable of cultivation.

Large grotto work requires a degree of skill that very few are possessed of to make it interesting.

EXPERIMENT XXX.

To make Artificial Coral.

410. To two drachms of fine vermillion add one ounce of clear resin, and melt them together. Having your branches or twigs peeled and dried, paint them over with this mixture while hot. The black thorn is the best branch for it. Hold them over a gentle fire, turning them round till they are perfectly covered and smooth. You may make white coral with white lead, and black with lamp-black.

411. Or melt two ounces of sulphur in a crucible, and add to it one ounce of vermillion; when thoroughly mixed, take off any pellicle of filth which may be on the top. Pour it, in a liquid state, on any coin, mould, &c. This substance will receive a very exact impression, and resemble coral. If at any time it should incline to a yellow colour, a feather dipped in nitric acid and rubbed over it, will restore its coralline appearance.

This substance is that used by seal engravers to take off impressions of stones; these impressions are called sulphurs.

EXPERIMENT XXXI.

To take Impressions from Leaves.

412. Take green leaves of trees or flowers, lay them between the leaves of a book till they are dry, then mix up some lamp-black with drying oil, and make a small dabber of some cotton wrapped up in a piece of soft leather. Put your colour upon a tile, and take some on your dabber.

Laying the dried leaf flat upon a table, dab it very gently with the oil colour, till the veins of the leaf are covered; but be careful not to dab it so hard as to force the colour between the veins Moisten a piece of paper, or rather have a piece laying between several sheets of moistened paper for several hours, and lay this over the leaf which has been blackened. Press it gently down, then subject it to the action of a press, or lay a heavy weight on it, and press it down very hard. By this means you obtain a very beautiful impression of the leaf and all the veins; even the minutest will be represented in a more perfect manner than they could be drawn with the greatest care. These impressions may also be coloured in the same manner as prints.

EXPERIMENT XXXII.

To preserve Birds.

413. The preserving of beautiful birds, with which some foreign countries abound, so as to retain their natural form and position, as well as the beauty of their colours and plumage, must be attended to with great care, lest they should be destroyed by insects, which has often been the case, to the great disappointment of the naturalist. After dissecting all the fleshy parts from the bones, and removing the entrails, eyes, brains, and tongue, the cavities and inside of the skin should be sprinkled with the following antiseptic powder.

	oz.
Muriate of mercury	2
Calcined nitrate of potass	2
——— Sulphate of alumine	2
Sulphur	4
Camphor	2
Pulverized black pepper	8
——— Tobacco	8

Mix the whole together, and keep it in a glass vessel, stopped up very close.

In Guiana, the number and variety of beautiful birds is so great, that several persons in the colony advantageously employ themselves in killing and preserving these animals for the cabinets of the naturalists in the different parts of Europe. The method of doing this, as related by Mr. Bancroft, is, to put the bird which is to be preserved, in a proper vessel, and cover him with high wines, or the first distillation of rum. In this spirit he is suffered to remain for twenty-four, or forty-eight hours or longer, according to his size, till it has penetrated through every part of his body. When this is done the bird is taken out, and his feathers, which are no ways changed by this immersion, are placed smooth and regular. He is then put into a machine made for the purpose, among a number of others; and his head, feet, wings, tail, &c. are placed exactly agreeable to life. In this posture they are all placed in an oven moderately heated, where they are slowly dried, and will ever after retain their natural position, without danger of putrefaction.

EXPERIMENT XXXIII.

To make Pictures of Birds, by Means of their own Feathers.

414. Get a thin board or pannel of deal, or wainscot, well seasoned, that it may not warp. Paste white paper over it, and let it dry. Take any bird you would represent, and draw its outline on the paper in the attitude you desire, and of the full size, adding what landscape, back ground, &c. you wish. This outline, so drawn, is afterwards to be filled up with the feathers from the bird, placing each feather in that part of the drawing corresponding to the part of the bird it was taken from.

Cover now the representation with several coats of strong gum water, letting it dry between each coat till it is of the thickness of a shilling. When your ground is thus prepared, take the feathers off from the bird, beginning at the tail or points of the wings, as you must work towards the head. These feathers are prepared by cutting off all the downy part; and the larger feathers have the insides of their shafts pared off, to make them lie flat. To lay them on, use a pair of small pliers to hold them by; and moistening the gummed ground with water, place each feather in its natural and proper situation. Keep each feather down, by putting a small leaden weight upon it, till you have another prepared to lay on. Be careful not to let the gum come through the feathers, as it smears them, and sticking to the bottoms of the weights, will be apt to pull the feathers off. When you have put on all the feathers, cut a piece of round paper, and colour it like the eye, which you may stick in its place; but the best way is to get eyes made of glass. The bill, legs, and feet, must be drawn and coloured from Nature. When it is finished and adjusted to your mind, lay a sheet of paper upon it, and upon that a heavy weight to press it; which must remain till the whole is quite dry.

EXPERIMENT XXXIV.

To take the Impression of a Butterfly.

415. Having caught a butterfly, kill it without spoiling its wings, contrive to spread these out as regularly as possible in a flying position; then, with a small brush or pencil, take a piece of white paper; wash part of it with gum water, afterwards, lay your butterfly on the paper, cut off the body close to the wings, throw it away, lay the paper on a smooth board, with the fly upwards; lay another paper over that, put the whole preparation into a screw press, and screw it hard down, or otherwise press it, for half an hour. Afterwards take off the wings of the butterfly, and you will find their perfect impression, with all the various colours marked distinctly, on the paper. When this is done, draw between the wings of your impression the body of the butterfly, and colour it after the insect itself.

EXPERIMENT XXXV.

The Velocipede.

416. This machine was the invention of Baron Charles de Drais, master of the woods and the forests of His Royal Highness the Grand duke of Baden.

Its theory is founded on the application of a wheel to the action of a man walking. The body is carried and supported, as it were, by two skaites, while the impulse is given by the alternate motion of *both* the legs.

As a horse draws, in a well-constructed carriage, both the carriage and its load much easier than he could carry the load alone on his back; so a man conducts, by means of the Velocipede, his body easier than if he had its whole weight to support on his feet. It is equally incontestible, that the Velocipede, as it makes but one impression, or rut, may always be directed on the best part of a road. On a hard road, the rapidity of the Velocipede resembles that of an expert skaiter; as the principles of the two motions are the same. In short, it runs a considerable distance while the rider is inactive, and with the same rapidity as when his feet are in motion; and, in a descent, it will beat the best horses in a great distance, without being exposed to the risks incidental to them, as it is guided by the mere gradual motion of the fingers, and may be instantly stopt by the feet.

It consists of two wheels, one behind the other, connected by a perch, on which a saddle is placed, for the seat of the traveller. The front wheel is made to turn on a pivot, and is guided in the same manner as a Bath-chair. On a cushion in front, the fore-arm is rested; and by this means the instrument and the traveller are kept in equilibrio.

Its Management.

The traveller having placed himself in the saddle, his elbows extended, and his body inclined a little forwards must place his arms on the cushion, and preserve his equilibrium by pressing lightly on that side which appears to be rising. The rudder (if it may be so called,) must be held by both hands, which are not to rest on the cushion, that they may be at full liberty, as they are as essential to the conduct of the machine as the arms are to the maintenance of the balance of it; (attention will soon produce sufficient dexterity for this purpose:) then, placing lightly the feet on the ground, long but very slow steps are to be taken, in a right line, at first; taking care to avoid turning the toes out, lest the heels should come in contact with the hind wheel. It is only after having acquired dexterity in the equilibrium and direction of the Velocipede, that the attempt to accelerate the motion of the feet, or to keep them elevated while it is in rapid motion, ought to be attempted.

The saddle may be raised or lowered, as well as the cushion, at pleasure: and thus suited to the height of various persons.

EXPERIMENT XXXVI.

To lay Mezzotinto Prints upon Glass.

417. Take a mezzotinto print; cut off the margin, and lay it flat in a dish of clear hot water; let it remain on the surface till it sinks. Then take it out, but be careful not to break it, press it betwixt clean cloths or papers, so that no water may appear on the surface, but let the print be quite damp: then lay it, face uppermost, on a flat table; have ready a plate of pure crown glass, void of spots or scratches; lay some Venice turpentine over one side of it with a soft brush, hold it to the fire a little, to make it run quite equal and thin; then let it fall gently on the print. Press it down, that the turpentine may stick to the print; press the print also with your fingers, from the middle to the edges of the glass, that no blisters may remain. Wet your print with a soft cloth, rub it gently with your finger, and the paper will peel off leaving only the impression upon the glass. When it is dry, wet it over with oil of turpentine till it is transparent, and set it by to dry, when it will be fit for painting. The colours used are the common oil colours, and there is nothing particular in the process.

EXPERIMENT XXXVII.

To make Artificial Pearls.

418. Take the *blay* or *bleak fish,* common in the Thames, scrape off the fine silvery scales from the belly; wash and rub these in water. Then suffer this water to settle, and a sediment will be found of an oily consistence. A little of this is to be

dropped into a hollow glass bead of a bluish tint, and shaken about, so as to cover all the internal surface. After this, the head is filled up with melted white wax, to give it solidity and weight.

EXPERIMENT XXXVIII.

To make variegated Powder.

419. Mix clean filings of copper, brass, iron, steel, and other metals. Put each of them separately into an iron vessel, and heat them till they change colour. The degree of heat can only be regulated by trial. Take these to a good flatting-mill, furnished with a funnel at top, and pass these filings through it, and you will procure a most beautiful sparkling powder of all sorts of lively colours.

EXPERIMENT XXXIX.

To make Artificial Petrifactions.

420. Put a quantity of pounded flour spar and a few bits of broken glass into a retort, pour upon them some sulphuric acid; fluoric acid gass will be disengaged, holding silex in solution. The substances to be made resembling petrifactions, as lizards, frogs, branches of trees, birds nests, &c. are now moistened with water, and placed in a vessel connected with the neck of the retort. The fluoric acid gas will be absorbed by the moisture adhering to the substances, and the silex precipitated upon them like a sort of hoar-frost, having a very beautiful appearance.

EXPERIMENT XL.

To make Cast-Steel.

421. Place small pieces of iron in a crucible, with a mixture of chalk or lime-stone and the earth of Hessian crucibles. Six parts of chalk and six of this earth are employed for twenty parts of the iron. The matters are so disposed, that, after fusion, the iron must be completely covered by them, to prevent it from coming into contact with the external air. The mixture is then gradually heated, and finally exposed to a heat capable of melting iron. If the fire be well kept up, an hour will be sufficient to convert two pounds of iron into excellent and exceedingly hard steel, capable of being forged. This is an advantage not possessed by steel made in the usual manner.

EXPERIMENT XLI.

To distinguish Iron from Steel.

422. Drop a little weak aqua-fortis on the metal; let it remain for a few minutes, then wash it off with water, and if it is steel, the spot will be black; but if iron, the spot will be whitish grey.

EXPERIMENT XLII.

Wine Test.

423. Keep equal parts of oyster shells and crude sulphur in a white heat for a quarter of an hour; when cold, mix the whole with an equal quantity of acidulous tartrite of potash, and put it into a strong bottle with common water for an hour, and then decant it into ounce bottles, with twenty drops of muriatic acid in each.

This liquor precipitates the smallest quantities of lead, copper, &c. from wines, in a very sensible black precipitate.

EXPERIMENT XLIII.

To produce Musical Sounds by the Flame of Hydrogen Gas in Tubes.

424. Prepare a large vial having a tight cork fitted to it, and into the cork insert a brass tube having a stop-cock. Put two ounces of iron filings or turnings into the vial, and pour over them an ounce of sulphuric acid, diluted with six ounces of water. The contents of the vial will now begin to effervesce, and hydrogen gas will escape. Place the cork in the vial and turn the stop-cock: the gas will now escape through the tube, and may be inflamed by a piece of lighted paper. Having previously procured an earthen or iron tube, two feet and a half long, and from one to two inches wide, bring it over the brass one in such a manner that one tube shall be inserted in the other for two or three inches. In a few seconds, as the flame continues to rush up, very strange but pleasing sounds will be produced, which may be varied by raising or depressing the large tube. These tones vary with the diameter, the thickness, the length, and the substance of the tube or jar; and also with changes in the jet.

Mr. Faraday, of the Royal Institution, has accounted for these phenomena in the following manner.

That the sounds are not owing to any action of aqueous vapour, was shewn by heating the whole tube above 212°; and still more evidently by an experiment, in which I succeeded in producing them from a jet of *carbonic oxyde*. That they do not originate in vibrations of the tube, caused by the current of air passing through it, was shewn by using cracked glass tubes, tubes wrapped up in a cloth, and, I have obtained very fine sounds by using a tube formed at the moment by rolling up half a sheet of cartridge paper, and keeping it in form by grasping it in the hand. The sounds have been accounted for, as well as their supposed peculiarity of production by hydrogen, by the supposition of a rapid current of air through the tube; but that this is not essential, is shewn by using bell-glasses and tubes closed at one end.

In examining attentively the appearance of a flame when introduced into a tube, it will commonly be found, that, on coming within its aperture, a current of air is established through the tube, which compresses the flame into a much smaller space; it is slightly lengthened, but its diameter is considerably diminished: on being introduced a little further, and as the tube becomes warm, this effect is increased; and the flame is gradually compressed a little above its commencement at the orifice of the jet, more than at any other part; a very faint sound begins to be heard, and as it increases, vibrations may be perceived in the flame, which are most evident in the upper part, but frequently also perceptible in the lower and smaller portion; these increase with the sound, which at last becomes very loud, and if the flame be further introduced into the tube, it is generally blown out.

The current is stronger in the axis of the tube than in any other part, in consequence of the friction at the sides and the position of the flame in the middle; and just at the entrance of the tube an additional effect of the same kind is produced, by the edge obstructing the air which passes near it; the air is therefore propelled on to the flame, and mingling with the inflammable matter existing there, forms portions of exploding mixtures, which are fired by the contiguous burning parts, and produce sound, in the manner already described, with a roaring flame; only, the impelled current being more uniform, and the detonations taking place more rapidly and regularly, and in smaller quantities, the sound becomes continuous and musical, and is rendered still more so by the effect of the tube in forming an echo.

That the roaring flame gives sound in consequence of explosion, can hardly be doubted; and the progress from a roar to a musical tone, is easily shewn in the following manner: take a lamp with a common cotton wick, and trim it with ether or alcohol; light it, and hold a tube over the flame, in a few seconds after introducing the flame, the draught will be sufficiently strong to blow it out, but if the current be obstructed by applying the fingers round the lamp at the bottom of the tube, combustion will go on, though irregularly; then, by a little management in admitting the air on one side or the other, and in greater or lesser quantity, it may be impelled on to the flame in various degrees, so as to produce a rough roaring sound, or one more continued and uniform, of a higher note, and more musical: and these may be made to pass into each other at pleasure: then, by substituting a stream of etherial vapour for the wick, which may be easily done from a small flask through a tube, the tones may be brought out more and more clearly, until they exactly resemble those of hydrogen.

A similar experiment may be made with coal gas; light a small Argand burner with a low flame, and bring a glass tube, which is a very little larger than the diameter of the flame, down upon it so as nearly to include it: the current of air will be impelled on the external part of the flame, it will remove the limit of combustion a little way up from the burner, that part of the flame will vibrate rapidly, burning with continued explosions, and an irregular tone will be obtained. Remove the burner, and fix on a long slender pipe to the gas tube, so as to afford a flame that may be introduced into the tube; light it, and introduce it about five or six inches, and a clear musical tone will be obtained.

That the tube is not essentially necessary is shewn by making it swell into a cylinder of three or four inches diameter, except above and below; or part of it may be extended into a globe. I took two air jars that were open above, but with contracted apertures; one of these was inverted over an inflamed jet of hydrogen, so as to form a lamp or bell glass about it: there was no effect of sound, because the downward currents from above interfered with the stream of air issuing up from beneath, and made it irregular; but placing the second receiver on the first, applying them edge to edge; so as to preserve the current of air upwards from disturbing forces, the sounds were immediately produced: and, lastly, I succeeded in obtaining the tones by the draught of a common chimney; for, by attaching a large inverted air jar to the end of a funnel pipe that came from the flue, closing the other lower opening into it, and introducing an inflamed jet of hydrogen within the lower contracted orifice of the glass, the sounds were produced.

That the same sounds may be obtained by means different to those above described, though depending on the same cause, is shewn by some experiments made by Sir H. Davy, in his first researches on the miners' safety lamp. Small wire-gauze safety lamps being introduced into air jars filled with explosive atmospheres, the gases burnt on the inside of the cylinder, and produced sounds similar to those obtained from a jet of flame in a tube.

Having thus endeavoured to account for the phenomenon of sounds produced by jets of flame in tubes and other vessels, I shall notice shortly the other combustible bodies I have tried.—Carbonic oxyde, olefiant gas, light hydrocarbonate, coal gas, sulphuretted hydrogen, and arsenurated hydrogen were burned at the end of a long narrow brass tube rising up from a transferring jar placed under pressure in a pneumatic trough. Ether was burned from the end of a tube fixed in a flask containing a small quantity which was heated; but a better method is to pour a little ether into a bladder, and then force common air in; so much ether rises in vapour as to prevent the mixture from detonating, and it may be pressed out, and burnt at the end of a tube. All these were very successful. Alcohol was more difficult to manage from being less volatile; but it succeeded when raised in vapour from a flask and burnt at a tube. In trials made with a wax taper, no distinct tone could be produced; but when the tube was made very hot, so as to assist the current through it, something like the commencement of a sound was heard at the moment the taper was blown out by the current.

Hydrogen is by far the best substance by which to produce these tones; and its superiority depends upon the low temperature at which it inflames, the intense heat it produces in combustion, and the small quantity of oxygen that a given bulk of it requires. It is in consequence less easily extinguished by the current than other gases, the current formed is more powerful and rapid, and an explosive mixture is sooner made. With gases producing little heat by combustion, and therefore occasioning but a feeble current, the effect is increased by first heating the tube at a fire, and when not heated previously, the tone is perceived to improve as the tube becomes hot from the flame playing in it.

Some variations of the form of the vessel inclosing the flame, and the material used, have been mentioned. Globes from seven to two inches in diameter, with short necks, give very low tones: bottles, Florence flasks, and phials have always succeeded: air jars from four inches diameter to a very small size, may be used. I constructed some angular tubes of long narrow slips of glass and wood, placing three or four together, so as to form a triangular or square tube, tying them round with packthread, and obtained tones from hydrogen.

EXPERIMENT XLIV.

To make Pearl-White.

425. Put good aqua-fortis into a Florence flask, gradually add to it bismuth broken into small pieces, till no more dissolves; let the solution remain till it is transparent. Add some water to this, and a white precipitate will be formed, which must be washed and dried. This is white oxyde of bismuth, commonly termed magistery of bismuth, or pearl-white.

This is used as a cosmetic, and sold by the perfumers; but it impairs the skin, blackening it by degrees; and it has besides, deletrious effects upon the constitution.

EXPERIMENT XLV.

Animalculæ Microscopic.

426. The surface of infused liquors is generally covered with a thin pellicle, easily broken, but acquiring thickness by standing; the greatest number of animalculæ are generally found in this superficial film.

To make an infusion of pepper. Cover the bottom of an open jar, about half an inch thick, with common black pepper bruised; pour as much soft water in the vessel as will rise about an inch above the pepper. The pepper and water are then well shaken; they must not be stirred after, but be left exposed to the air for a few days, when a thin pellicle will be formed on the surface of the water, containing millions of animalculæ.

To procure the eels in paste, boil a little flour and water till it becomes of a moderate consistence; expose it to the air in an open vessel, and beat it together from time to time, to prevent the surface from growing hard or mouldy: after a few days, especially in summer time, it will turn sour; then, if it be examined with attention, you will find myriads of eels on the surface. Apply them to the microscope on a slip of flat glass, first putting on it a drop of water, taken up by the head of a pin, for them to swim in.

EXPERIMENT XLVI.

To break up Logs of Wood.

427. The usual way of breaking up logs of wood for fuel, is by axes, and driving wedges in. This is particularly laborious in roots of trees. It is also sometimes done by gunpowder, as stones and rocks are blasted; but this also is troublesome.

A better method of performing this operation is to bore a hole with an auger, and introduce a charge of powder. An iron screw, with a good thread, having a hole bored through its axis, is then introduced into the hole, and turned till it come near to the powder. While the screw is putting in, a wire is kept in the hole through its axis, but afterwards drawn out, and a piece of twine dipped in a solution of nitre put into its place. This quick match is set fire to, and by slow burning, affords time for the operator to retire before the gunpowder fires.

Ry this means, any roots or old stumps of trees may be easily broken up.

EXPERIMENT XLVII.

The Automaton Chess-player.

428. The automaton chess-player was constructed by Monsieur de Kempelen, an Hungarian gentleman, and one of the Aulic Council. He was well skilled in mechanics, and an admirable chess-player. Being at Vienna in 1769, he had the honour of playing chess with the Empress Queen, Maria Theresa, who said to him, "I believe, Monsieur de Kempelen, you think I play very ill." To which he answered, "Indeed, Madam, I could make an automaton, which can play as well as your Majesty." The Empress took him at his word, and drew a promise from him that he would produce such an ingenious

piece of mechanism. This he executed in the course of six months, and brought it to Vienna, where it was exhibited, to the delight and astonishment of all who saw it.

After Monsieur de Kempelen had finished and exhibited his automaton, and had returned to his house, he undertook many other mechanical works of a more useful description, and neglected this fine specimen of art, so that it gradually became rusty, and out of order. But when the King and Queen of Sweden visited Vienna, under the titles of Count and Countess of the North, the Emperor Joseph, recollecting the automaton, and thinking it might amuse his royal guests, sent for it, and Monsieur de Kempelen, to Vienna. Its reparation occupied him for five weeks; after which it was shewn to the Court, with the greatest applause; and he was recommended to take it with him into foreign countries for the purpose of exhibition. Having accordingly obtained from the Emperor leave of absence for two years, Monsieur de Kempelen set out on his tour, and visited many of the capitals of Europe with the most abundant success. His first exhibition was at Paris, where he also shewed a speaking figure, capable of uttering a few words.

This wonderful piece of mechanism has for many years lain dormant. It was brought to England in the year 1817, and exhibited in the great room, Spring Gardens, London, and in other places, to the admiration and satisfaction of thousands. We shall here give a description of its mechanism and operations. The room, where it is exhibited, has an inner apartment, within which appears the figure of a man, as large as life, dressed after the Turkish fashion, sitting behind a chest three feet and a half in length, two feet in breadth, and two feet and a half in height, to which it is attached by a wooden seat. The chest is placed upon four castors; and, together with the figure, may be moved to any part of the room. On the plain surface, formed by the top of the chest, in the centre, is a raised immovable chess-board, upon which the figure has its eyes fixed; its right arm and hand being extended on the chest, and its left arm holding a Turkish tobacco-pipe. The exhibitor begins, by wheeling the chest to the entrance of the apartment within which it stands, and in face of the spectators. He then opens certain doors in the chest, two in front, and two at the back at the same time, pulling out a long shallow drawer at the bottom, which contains the chess-men, a cushion for the arm of the figure to rest upon, and some counters. Two lesser doors, and a green cloth screen, contrived in the body of the figure, and its lower parts, are likewise opened, and the Turkish robe which covers them is raised; so that the construction both of the figure and chest internally is displayed. In this state, the automaton is moved round for the examination of the spectators; and to banish all suspicion that any living thing is concealed within any part of it, the exhibitor introduces a lighted candle into the body of the chest and figure, by which the interior of each is, in a great measure, rendered transparent, and the most secret corner is shewn. Here it may be observed, that the same precaution to remove suspicion is used, if requested, at the close as at the commencement of a game of chess with the automaton.

The chest is divided, by a partition, into two unequal chambers. That to the right of the figure is the narrowest, and occupies scarcely one-third of the body of the chest. It is filled with little wheels, levers, cylinders, and other machinery used in clock-work. That to the left contains a few wheels, some small barrels with springs, and two quarters of a circle placed horizontally. The body and lower parts of the figure contain tubes, which seem to be conductors to the machinery. After a sufficient time, during which each spectator may satisfy his scruples and his curiosity, the exhibitor re-closes the doors of the chest and figure, and the drawer at bottom; makes some arrangements in the body of the figure; winds up the works with a key inserted into a small opening on the side of the chest; places a cushion under the left arm of the figure, which now rests upon it; and invites any individual present to play a game of chess.

In playing a game, the automaton makes choice of the white pieces, and always has the first move. These are small advantages towards winning the game, which are cheerfully conceded. It plays with the left hand, the right arm and hand being constantly extended on the chest, behind which it is seated. This slight incongruity, proceeded from absence of mind in the inventor, who did not perceive his mistake till the machinery of the automaton was too far completed to admit of the mistake being rectified. At the commencement of a game, the automaton moves its head, as if taking a view of the board; the same motion occurs at the close of a game. In making a move, it slowly raises its left arm from the cushion placed under it, and directs it towards the square of the piece to be moved. Its hand and fingers open on touching the piece, which it takes up, and conveys to any proposed square. The arm then returns with a natural motion to the cushion, upon which it usually rests. In taking a piece, the automaton makes the same motions of the arm and hand to lay hold of the piece, which it conveys from the board; and then, returning to its own piece, it takes it up, and places it on the vacant square. These motions are performed with perfect correctness; and the dexterity with which the arm acts, especially in the delicate operation of castling, seems to be the result of spontaneous feeling, bending at the shoulder, elbow, and knuckles, and cautiously avoiding to touch any other piece than that which is to be moved, nor ever making a false move.

After a move made by its antagonist, the automaton remains for a few moments inactive, as if meditating its next move; upon which the motions of the left arm and hand follow. On giving check to the king, it moves its head as a signal. When a false move is made by its antagonist, which frequently occurs through curiosity to observe in what manner the automaton will act, (as, for instance, if a knight be made to move like a castle,) the automaton taps impatiently on the chest with its right hand, replaces the knight on its former square, and, not permitting its antagonist to recover his move, proceeds immediately to move one of its own pieces: thus appearing to punish him for his inattention. The little advantage in play which is hereby gained, makes the automaton more a match for its antagonist; and seems to have been contemplated by the inventor as an additional resource towards winning the game.

It is of importance that the person matched against the automaton, should be attentive, in moving a piece, to place it precisely in the centre of its square; otherwise the figure, in attempting to lay hold of the piece, may miss its hold, or even sustain some injury in the delicate mechanism of the fingers. When the person has made a move, no alteration in it can take place; and if a piece be touched, it must be played somewhere. This rule is strictly observed by the automaton. If its antagonist hesitate to move for a considerable time, it taps smartly on the top of the chest with the right hand, which is constantly extended upon it, as if testifying impatience at his delay. During the time that the automaton is in motion, a low sound of clock-work is heard, which ceases soon after its arm returns to the cushion, and then its antagonist may make his move. The works are wound up at intervals, after ten or twelve moves, by the exhibitor, who is usually employed in walking up and down the apartment in which the automaton is shewn; approaching the chest however, from time to time, especially on its right side.

EXPERIMENT XLVIII.

To purify Fish Oil.

429. To a gallon of crude stinking oil, put a pint of water poured off from two ounces of slacked lime; stir the mixture several times for twenty-four hours; then let it stand a day, and the lime water will sink below the oil, which being carefully separated from it will be purified.

Another Method by which to purify it still more.

With a gallon of crude stinking oil, mix a quarter of an ounce of powdered chalk, a quarter of an ounce of slacked lime, and half a pint of water; stir them together, and when they have stood some hours, add a pint of water, and two ounces of pearl-ashes, place the mixture over a fire to simmer till the oil appears of a a light amber colour, and has lost all smell, except a hot, greasy soap-like scent. Then add half a pint of water in which an ounce of salt has been dissolved, and having boiled it half an hour, pour the mixture into a proper vessel, and let it stand for some days, till the oil and water separate.

If this operation be repeated several times, diminishing each time the quantity of ingredients one half, the oil will be brought to a light colour, and rendered as sweet as the common spermaceti oil.

Oil purified in this manner, burns much better, and answers the purposes of the woollen manufacture. If an oil be wanted thicker and more unctuous, it may be rendered so by the addition of tallow.

EXPERIMENT XLIX.

Mode of analysing Minerals, and reducing Metals from their Oxydes, by the Blowpipe.

430. The substance to be submitted to the action of the blowpipe should be placed on a piece of charcoal, or in a small small spoon of platina, gold, or silver; or, according to Saussure, a plate of cyamite may sometimes be used. Charcoal from the fire is to be preferred, which should be well ignited and dried, that it may not crack. The sides, and not the

ends, of the fibres must be used; otherwise the substance to be fused spreads about, and a round head will not be formed. A small hole is to be made in the charcoal, which is best done by a slip of plate iron bent longitudinally. Into this hole the substance to be examined must be put in very small quantity; if a very intense heat is to be used, it should not exceed the size of half a peppercorn.

The metallic spoons are used when the substance to be examined is intended to be exposed to the action of heat only, and might undergo some change by immediate contact with the charcoal. When the spoon is used, the flame of the blow-pipe should be directed to that part of it which contains the substance under examination, and not be immediately applied to the substance itself. The handle of the spoon may be inserted into a piece of charcoal; and, if a very intense heat be required, the bowl of the spoon may be adapted to a hole in the charcoal. Small portions may be taken up by platina forceps. Salts and volatile substances are to be heated in a glass tube closed at one end, and enlarged according to circumstances, so as to form a small mattrass.

When the alteration which the substance undergoes by the mere action of heat has been observed, it will be necessary to examine what further change takes place when it is melted with various fluxes, and how far it is capable of reduction to the metallic state.

These fluxes are,

1. Microcosmic salt; a compound of phosphoric acid, soda, and ammonia.

2. Subcarbonate of soda, which must be free from all impurity, and especially from sulphuric acid, as this will be decomposed, and sulphuret of soda will be formed, which will dissolve the metals we wish to reduce, and produce a bead of coloured glass with substances that would otherwise give a colourless one.

3. Borax, which should be first freed from its water of crystallization.

These are kept powdered in small flasks; and, when used, a sufficient quantity may be taken up by the moistened point of a knife: the moisture causes the particles to cohere, and prevents their being blown away when placed on the charcoal. The flux must then be melted to a clear bead, and the substance to be examined placed upon it. It is then to be submitted to the action, first of the exterior, and afterwards of the interior, flame; and the following circumstances to be carefully observed:

1. Whether the substance is dissolved; and, if so,
2. Whether with or without effervescence, which would be occasioned by the lion of carbonic acid, sulphureous acid, oxygen, gaseous oxyde of carbon &c.
3. The transparency and colour of the glass while cooling.
4. The same circumstances after cooling.
5. The nature of the glass formed by the exterior flame, and
6. By the interior flame.
7. The various relations to each of the fluxes.

It must be observed, that soda will not form a bead on charcoal, but with a certain degree of heat will be absorbed. When, therefore, a substance is to be fused with soda, this flux must be added in very small quantities, and a very moderate heat used at first, by which means a combination will take place, and the soda will not be absorbed. If too large a quantity of soda has been added at first, and it has consequently been absorbed, a more intense heat will cause it to return to the surface of the charcoal, and it will then enter into combination.

Some minerals combine readily with only very small portions of soda, but melt with difficulty if more be added, and are absolutely infusible with a larger quantity: and when the substance has no affinity for this flux, it is absorbed by the charcoal, and no combination ensues.

When the mineral or the soda contains sulphur or sulphuric acid, the glass acquires a deep yellow colour, which by the light of a lamp appears red, and as if produced by copper.

If the glass bead becomes opaque as it cools, so as to render the colour indistinct, it should be broken, and a part of it mixed with more of the flux, until the colour becomes more pure and distinct. To render the colour more perceptible, the bead may be either compressed before it cools, or drawn out to a thread.

When it is intended to oxydate more highly a metallic oxyde contained in a vitrified compound with any of the fluxes, the glass is first heated by a strong flame, and, when melted, is to be gradually withdrawn from the point of the blue flame. This operation may be repeated several times, permitting the glass sometimes to cool, and using a jet of large aperture with the blow-pipe.

The reduction of metals is effected in the follow manner:—The glass bead, formed after the manner already pointed out, is to be kept in a state of fusion on the charcoal as long as it remains on the surface, and is not absorbed, that the metallic particles may collect themselves into a globule. It is then to be fused with an additional quantity of soda, which will be absorbed by the charcoal, and the spot where the absorption has taken place is to be strongly ignited by a tube with a small aperture. By continuing this ignition, the portion of metal, which was not previously reduced, will now be brought to a metallic state; and the process may be assisted by placing the lead in a smoky flame, so as to cover it with soot that is not easily blown off.

The greatest part of the beads which contain metals are frequently covered with a metallic splendour, which is most easily produced by a gentle, fluttering, smoky flame, when the more intense heat has ceased. With a moderate heat, the metallic surface remains: and, by a little practice, it may generally be known whether the substance under examination contains a metal or not. But it must be observed, that the glass of borax sometimes assumes externally a metallic splendour.

When the charcoal is cold, that part impregnated with the fused mass should be taken out with a knife, and ground with distilled water in a crystal, or, what is much better, an agate mortar. The soda will be dissolved; the charcoal will float, and may be poured off; and the metallic particles will remain in the water, and may be examined. In this manner most of the metals may be reduced.

EXPERIMENT L.

Mr. Hare's (of Philadelphia) Experiments on refractory Substances, by the Oxy-Hydrogen Blow-pipe.

431. *Silex*—being in a fine powder, when moistened with water, became agglutinated by the heat, and was then perfectly fused into a colourless glass.

Alumine—perfectly fused into a milk-white enamel.

Barytes—fused immediately, with intumescence, owing to water; it then became solid and dry, but soon melted again into a perfect globule, a greyish-white enamel.

Strontites—the same.

Glucine—perfectly fused into a white enamel.

Zircon.—the same.

Lime—When the compound flame fell upon the lime, the splendour of the light was perfectly insupportable by the naked eye; and when viewed through deep-coloured glasses (as indeed all these experiments ought to be,) the lime was seen to become rounded at the angles, and gradually to sink, till, in the course of a few seconds, only a small globular protuberance remained, and the mass of supporting lime was also superficially fused at the base of the column, through a space of half an inch in diameter. The protuberance, as well as the contiguous portion of lime, was converted into a perfectly white and glistening enamel: a magnifying glass discovered a few minute pores, but not the slightest earthy appearance.

Magnesia—The escape of the water caused the vertex of the cone to fly off in repeated flakes, and the top of the frustum, that thus remained, gave nearly as powerful a reflection of light as the lime. After a few seconds, the piece being examined with a magnifying glass, no roughnesses or earthy particles could be perceived on the spot, but a number of glassy smooth protuberances, whose surface was a perfectly white enamel.

Platinum—was not only melted, but volatized with a strong ebullition.

Rock Crystal—transparent and colourless. This mineral was instantly melted into a beautiful white glass.

Common Quartz—fused immediately into a vitreous globule.

Gun Flint—melted with equal rapidity: it first became white, and the fusion was attended with ebullition and a separation of numerous small ignited globules, which seemed to burn away as they rolled out of the current of flame: the product of this was a beautiful splendid enamel.

Chalcedony—melted rapidly, and gave a beautiful bluish-white enamel, resembling opal.

Oriental Carnelian—fused with ebullition, and produced a semi-transparent white globule, with a fine lustre.

Red Jasper—from the Grampians, was slowly fused with a sluggish effervescence: it gave a greyish black slag, with white spots.

Smoky Quartz—or smoaky topaz, melted into a colourless globule.

Beryl—melted instantly into a perfect globule, and continued in a violent ebullition as long as the flame was applied and when, after the globule became cold, it was heated again; the ebullition was equally renewed: the globule was a glass, of a beautiful bluish milky white.

Emerald of Peru—The same; only the globule was green, and perfectly transparent.

Olivin—fused into a dark-brown globule, almost black.

Vesuvian—instantly melted into a beautiful green glass.

Leucite—instantly fused into a perfectly transparent white glass: the fusion was attended with strong ebullition, and many ignited globules darted from it, and burnt in the air, or rolled out upon the charcoal and then burned. Were they not potassium? This stone contains full 20 per cent. of potash.

Chrysoberyl—(Cymophane of Halley) was immediately fused into a greyish-white globule.

A crystallized Mineral—from Haddam, Connecticut; according to the Abbe Hauy, it is *chrysoberyl;* according to Colonel Gibbs, *corundum*: it fused with ebullition and scintillations, and produced a very dark globule, almost black.

Topaz—of Saxony, melted with strong ebullition, and became a white enamel.

Sappar or *Kyanile*—perfectly and instantly fused, with ebullition, into a white enamel.

Corundum of the East Indies—was immediately and perfectly fused into a gray globule.

Corundum of China—the same, with active ebullition.

Zircon of Ceylon—melted with ebullition into a white enamel.

Hyacinth of Expailly—fused into a white enamel.

Cinnamon stone—instantly fused into a black globule, with violent ebullition.

Spinelle Ruby—fused immediately into an elliptical red globule.

Steatite—melted with strong ebullition into a grayish stag.

——Porcelain, common pottery, fragments of Hessian crucibles. Wedgewood's ware, various natural clays, as pipe and porcelain clay, fire and common brick, and compound rocks, &c. were fused with equal ease.—In subsequent experiments, gold, silver, platina, and most of the metals, were not only volatilized, but burnt with peculiar flames.

CHAPTER XII.

OPTICS.

SECTION I.

DEFINITIONS.

432. OPTICS is the science of vision, and it includes Dioptrics, Catoptrics, and Chromatics.

Dioptrics is the science of refracted vision, or that which considers the several refractions of light in passing through different media, as air, water, glass, &c. and especially lenses.

Catoptrics is the science of reflected vision, and explains the appearances of objects seen by the reflection of polished surfaces.

Chromatics is that part of the science of optics which explains the several properties of the colours of light, and of natural bodies.

SECTION II.

OF LIGHT.

433. Light consists of an inconceivably great number of particles flowing from a luminous body in all directions. A *ray of light* is the motion of a single particle, which is represented by a straight line.

Light travels from the sun to the earth in about eight minutes, or at the rate of two hundred thousand miles in a second of time.

The velocity of light was discovered by observing the eclipses of Jupiter's satellites, which are found to happen 16 minutes later than the calculated time, if the earth is in that part of the orbit which is farthest from Jupiter, than if it were in the opposite part of the heavens: that is, the light from the satellites of Jupiter is 16 minutes in travelling over the length of the earth's orbit, or 190 millions of miles.

434. The particles of light move in all directions without the least disturbance, and hence it is inferred they must be inconceivably small.

Experiment. Make a small pin-hole in a piece of brown paper, and through this may be seen at once a great variety of objects, as trees, houses, &c. Now as we see objects only by the particles of light reflected from them to the eye, it is evident that these particles must cross each other in passing through the hole in the paper, which they do without being in the least disturbed by the motion.

A candle placed on an eminence in a dark night may be seen a mile or two all round, which proves that light moves in all directions, and as a single candle may be seen in all that space in an instant after it is lighted, we may be sure the particles must be very small.

435. Light always moves in a straight line, for if you look at an object through a straight tube, you see it by means of the rays of light flowing from it; but point a bended tube toward the sun, and its rays will not pass to the other end.

The shadows which are cast by opaque bodies, as a building, &c. prove also that the rays of light move in a straight line only. The particles flowing from a luminous body, as the sun, or a candle, give us the idea of light; these particles falling on bodies, as the furniture of a room, and reflected to our eyes, furnish us with the idea of light.

Go into a darkened room, and you have no idea what that room contains; admit the rays of light, and owing to the velocity with which they travel, they flow upon all the bodies in the apartments at the same instant, and are reflected to the eyes, thereby exciting in the mind the idea of these bodies.

436. Every part of a visible body reflects the rays of light in all directions.

For let a person stand where he will, he sees every part of the surface of a body which is towards him, when no object obstructs the rays.

437. The intensity or degree of light decreases as the square of the distance from the luminous body increases.

If you stand one yard, two yards, three yards, &c. from a candle, the proportion of light will be as one, one-fourth, one-ninth; that is, at two yards distance, you have only the fourth part of the benefit of the candle that you would have at a yard's distance only; and at three yards distance the benefit would be only one-ninth as great as at one yard distance only; at four yards it would be only one-sixteenth, and so on.

The planet Herschel is about twenty times as far from the sun as the earth; it will therefore enjoy 20 × 20 times, or 400 times less of the benefits of light and heat than we experience.

SECTION III.

OPTICAL DEFINITIONS.

438. A slender portion of rays separated from the rest, is called a *pencil of rays*.

Pencils of rays are either conical or cylindrical; the axis of a pencil being the same with the axis of the cone or cylinder. By a medium, is meant any pellucid or transparent body, which suffers light to pass through it, as water, air, and glass.

Parallel rays are those which move always at the same distance from each other. If rays continually recede from each other, they are said to *diverge*: and if they continually approach towards each other, to *converge*.

The point at which converging rays meet, is called the *focus*. The point towards which they tend, but which they are prevented from coming to, by some obstacle, is called the *imaginary focus*.

When rays, after passing through one medium, on entering another medium of different density, are bent out of their former course, and made to change their direction, they are said to be *refracted*. When they strike against a surface, and are sent back again from the surface, they are said to be *reflected*.

A *lens* is glass ground into such a form, as to collect or disperse the rays of light which pass through it. These are of different shapes, and from thence receive different names.

A plano-convex has one side flat, and the other convex; a plano-concave is flat on one side, and concave on the other; a double convex, is convex on both sides; a double concave, is concave on both sides; a *meniscus*, is convex on one side, and concave on the other, like the common watch-glass.

A line passing through the centre of a lens is called its *axis*.

A *prism*, is a triangular piece of glass, which has the power of separating the rays of light into their component parts.

SECTION IV.

REFRACTION.

439. If parallel rays fall upon a plano-convex lens, they will be so refracted as to unite in a point behind, called the focus, which point is at a distance equal to the *diameter* of the sphere of which the lens is a portion.

If parallel rays fall on a double convex lens, they will be refracted and unite at a distance equal to the radius of a sphere, of which the lens is a portion.

440. All the rays of the sun that pass through a lens are collected in the focus; and the force of the heat at the focus is to the common heat of the sun, as the area of the glass is to the area of the focus.

If the area of the lens be three inches, and that of the focus only one-fourth of an inch, then the areas of all circles being as the squares of their diameters, they will be to one another $1^2 : 12^2$, or $1 : 144$.

441. All common burning glasses are double convex lenses, which is the reason why globular decanters filled with water and left incautiously exposed to the direct rays of the sun, have been known to burn furniture.

442. The *camera obscura* consists of a double convex glass so adapted as to fit to a hole in the shutter of a darkened chamber: behind this is fixed at a proper distance, a sheet of paper, on which a picture of the external objects will be painted.

In a *portable camera obscura*, the lens is fixed in a box, and by means of a mirror placed at a proper angle, the picture is reflected upon oiled paper, on which the artist sketches his draught.

443. The *magic lantern* depends likewise on the double convex lens, which is fitted to a hole in a dark lantern, and little pictures painted in transparent colours on slips of glass are passed successively

between the lens and the candle in the lantern. These pictures are then painted on the wall of the room or a sheet, &c. that is placed to receive them. The figures must be inverted in the lantern if they are to be upright on the wall.

444. The *phantasmagoria* is like the magic lantern, only instead of painting the figures on transparent glass, all the glass is opaque except the figure only, which being painted in transparent colours, the light shines through it, and no light can fall upon the screen but what passes through the figure. The screen is very thin silk placed between the spectators and the lantern, and by moving the lantern backwards or forwards the figures seem to recede or approach.

445. The multiplying-glass is on the principle of the plano-convex lens, but instead of a convex side, it is cut into several distinct surfaces, so that instead of seeing one object through it, we see as many as the glass has plane surfaces.

SECTION V.

REFLECTION.

446. **When the rays of light strike against a surface and are driven back from it, they are said to be *reflected*.**

All objects are rendered visible by the light they reflect from their surface; and glass itself is distinguished by the rays it reflects.

Bodies with polished surfaces, which reflect the rays of light copiously, are called *mirrors*. These are generally smooth plates of glass, tinned or quicksilvered on the back part, and called looking-glasses.

Mirrors are either *plane*, *convex*, or *concave*. The first sort reflects the rays of light in a direction exactly similar to that in which they fall upon it, and therefore represents bodies of their natural magnitude.

A ray coming from any luminous body, which falls upon a reflecting surface, is termed the *incident* ray. A ray of light striking perpendicularly upon a plane mirror, is reflected back in the same direction; but those rays which strike it obliquely, are reflected back, in an opposite direction, but with the same obliquity; consequently the angle of reflection is exactly equal to the angle of incidence.

If a pencil of parallel rays be incident on a *convex* spherical speculum, they will be reflected diverging: and the focus of the reflected rays will bisect the radius which is parallel to the incident rays, and be virtual.

If a radiant object be placed before a convex speculum, 1. The image will appear behind the speculum. 2. It will appear erect. 3. It will be less than the object. 4. As the object approaches the speculum, the image will likewise approach the speculum; and increase, till at length, when the object touches the speculum, the object and image will meet, and be equal. 5. The image will be convex towards the object.

If a pencil of parallel rays fall on a spherical *concave* speculum, they will be reflected converging: and the focus of the reflected rays will bisect the radius that is parallel to the incident rays, and be real.

If rays diverging from a radiant placed in the centre, fall on a concave spherical speculum, the focus will coincide with the centre, and the image with the object.

If the radiant be placed between the centre and the principal focus, the image will be formed at the other side of the centre; and the distance of the radiant from the speculum will be to its distance from the centre, as the distance of the focus from the speculum to its distance from the centre.

If the radiant be placed in the principal focus, the rays will be reflected parallel.

If the radiant be placed between the principal focus and the speculum, the rays will be reflected diverging from an imaginary focus behind the speculum; and the position of the focus will be determined in the same manner as before.

The image is inverted or erect with respect to the object, according as they are at different sides, or on the same side of the centre of the speculum.

The degrees of heat generated in the foci of different specula when exposed to the sun's rays, are as their areas directly, and inversely as the squares of their focal lengths. And the heat generated in the focus of a speculum employed as a *burning-glass* is to the sun's direct heat, as the area of the image.

SECTION VI.

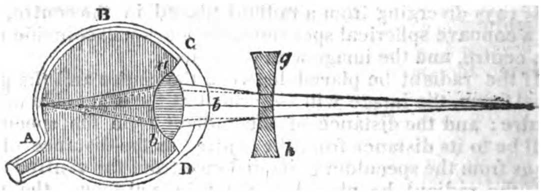
OF THE EYE.

447. The eye consists of a transparent horny coat on its outside, called the *cornea;* within it, is a pure liquid called the *aqueous humour;* and within the aqueous humour, is a lens, like a spectacle glass, called the *crystalline humour*.

Beyond that, is a Jelly-like humour, called the *vitreous humour*, filling the ball of the eye; and at the back of the eye, is spread the optic nerve, *retina*, or fine net-work, to receive the impressions of the rays of light.

The horny coat, the *lens*, called the crystalline humour, and the other transparent humours, answer the general purpose of one spectacle-glass, with nice and wonderful powers of adaptation.

A B C D is a section of the globe of the eye, the three concentric circles representing the three coats.



The external coat, or membrane, is called the *sclerotica;* it is strong, elastic, and of a white colour, resembling parchment: the hinder part is very thick and opaque, but it grows gradually thinner, as it approaches the part where the white of the eye terminates. A circular portion of it in front, is perfectly transparent, and more convex than the rest: this is called the *cornea*, as C D.

Immediately adherent to the sclerotica within, is the *choroides*, which is a soft and tender coat, composed of numerous vessels. This membrane is inwardly of a russet-brown colour, inclining to black. Like the sclerotica, it is distinguished into two parts; the fore-part is called the *iris*, while the hinder part retains the name of choroides. The fore-part commences at the place where the cornea begins: here it

attaches itself more strongly to the sclerotica by a cellular substance, forming a kind of white narrow circular rim, called the *ciliary circle.* The choroides separates at this place from the sclerotica, changing its direction, turning, or rather folding, directly inwards, towards the axis of the eye, cutting the eye, as it were, transversely. The iris is composed of two kinds of muscular fibres; one sort tending, like radii, towards the centre of the circle, and the other forming a number of concentric circles round the same centre. The central part of the iris is perforated, and the orifice, which is called the *pupil*, is varied in magnitude by the action of the two sets of fibres composing the iris.

When a very luminous object is viewed, the circular fibres contract, and diminish the orifice; and on the other hand, when the objects are dark and obscure, the radial fibres of the iris contract, and enlarge the pupil so as to admit a greater quantity of light. The iris is differently coloured in different persons: in some it is blue, in others brown, or of a hazel colour.

The whole of the choroides is opaque, by which means no light is allowed to enter into the eye, but what passes through the pupil. To render this opacity more perfect, and the chamber of the eye still darker, the posterior surface of this membrane is covered all over with a black mucus, called the *pigmentum nigrum.*

From the part of the choroides, called the ciliary circle, arise a set of radial fibres, turning inwards towards the centre of the eye, and filled up between with a black mucus, giving it the appearance of a membrane, C *a*, D *b*. This serves to support the crystalline humour hereafter described; and is called the *ligamentum ciliare*, or ciliary ligament.

The third and last membrane of the eye is called the *retina.* This is a fine and delicate membrane, being an expansion of the medullary part of the optic nerve. It is spread like a net all over the concave surface of the choroides, and terminates at the ciliary ligament. It serves to receive the images of objects produced by the refraction of the different humours of the eye, and these objects are painted, as it were, upon its surface. It is itself transparent, but appears black, by reason of the pigmentum nigrum spread underneath it.

From the hinder part of the eye (but not from the centre part) proceeds the *optic* nerve A, which conveys to the brain the sensation produced upon the retina.

The coats of the eye which invest and support each other after the manner of the concentric coats of an onion, or other bulbous root, inclose three transparent bodies, called the *aqueous*, *crystalline*, and *vitreous humours*.

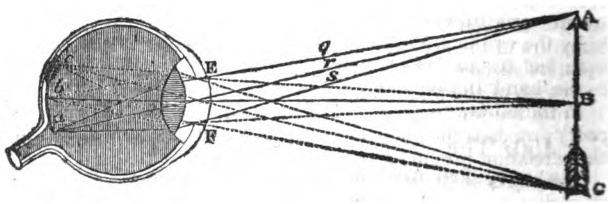
The *aqueous* humour is the most fluid, being thin and clear like water: it fills up the space between the cornea and ciliary ligament, being divided into two portions by the iris, which swims in it. These are called the anterior and posterior portions of the aqueous humour.

The *crystalline* is the second humour of the eye, and is as transparent as the purest crystal; but in consistence it resembles a hard jelly, growing somewhat softer from the middle towards the edges. Its form is that of a double convex lens, but more convex on the interior than on the exterior surface. This humour is contained in a very strong and transparent membrane, called the *arachnoides*, and is suspended behind the aqueous humour by the ligamentum ciliare.

The *vitreous* is the third humour of the eye; and it receives its name, like the others, from its appearance, which is like melted glass. It is not so hard as the crystalline, nor so liquid as the aqueous humour. It fills all the interior chamber of the eye, behind the crystalline humour.

Of the Manner in which Vision is performed.

448. As every point of an object, A B C, sends out rays in all directions, some rays from every point on the side next the eye, will fall upon the cornea, between E and F; and by passing on through the humours and pupil of the eye, they will be converged to as many points on the retina, or bottom, of the eye, and will thereon form a distinct inverted picture, *c b a*, of the object.



Thus the pencil of rays, $q\ r\ s$, that flow from the point A of the object, will be converged to the point a on the retina; those on the point B, will be converged on the point b; those from the point C, will be converged to the point c; and so of all the intermediate points, by which means the whole image $a\ b\ c$ is formed, and the object made visible; although it must be owned, that the method by which this sensation is carried from the eye, by the optic nerve, to the common sensorium in the brain, and there discerned, is above the reach of our conception.

But we may demonstrate experimentally that vision is effected in this manner.

Take a bullock's eye while it is fresh, and having cut off the three coats from the back part, quite to the vitreous humour, put a piece of white paper over that part, and hold the eye towards any bright object, and you will see an inverted picture of the object upon the paper.

449. Seeing that the image is inverted, many have wondered why the object appears, as it really is, upright; but we are to consider, that inverted is only a relative term; and that there is a very great difference between the real object and the means or image by which we perceive it.

When all the parts of a distant prospect are painted upon the retina, they are all right with respect to one another, as well as the parts of the prospect itself; and we can only judge of an object's being inverted, when it is turned reverse to its natural position, with respect to other objects which we see and compare it with. If we lay hold of an upright stick in the dark, we can tell which is the upper or lower part of it, by moving our hand upward or downward; and who does not know very well that he can feel the upper end by moving his hand downward? Just so we find by experience, that upon directing our eyes towards a tall object, we cannot see its top by turning our eyes downward, nor its base by turning our eyes upward; but must trace the object the same way by the eye to see it from head to foot, as we do by the hand to feel it; and as the judgment is informed by the motion of the hand in one case, so it is also by the motion of the eye in the other.

450. The diameters of images at the bottom of the eye, are proportional to the angles which the

objects subtend at the eye, the same as in a lens; and are reciprocally as the distances of the same object viewed in different places.

The eye is not in action any more than a camera obscura, for the rays of light flowing from all the points of an object, through the pupil of the eye, do, by the refraction of its humours, paint the image of that object in the bottom of the eye: so also it is in the camera obscura, where all the rays refracted by a lens in the window-shutter, or passing through a small hole in it, paint the image on the opposite wall.

451. The general properties of the eye are these:

1. It can only see a very small part of an object distinctly at once; and therefore the eye is forced to turn itself successively to the several parts of the object it wants to view, that they may fall near the axis of the eye, where alone distinct vision is performed.

2. When any point of an object is seen distinctly with both eyes, the axes of both eyes are directed to that point, and meet there; for the optic nerves are so framed, that the correspondent parts in both eyes, lead to the same place in the brain, and give but one sensation. An image is twice as bright with both eyes as with one. If the axes of both eyes be not directed to the object, that object will appear double, as the pictures in the two eyes do not fall upon correspondent or similar parts of the retina.

3. The best eye can hardly distinguish any object which at the eye subtends an angle less than half a minute; if the distance of two stars in the heavens be not greater than one minute, they will appear as one.

4. Though men may see distinctly at different distances, by altering the position and figure of the crystalline, yet they can only see distinctly within certain limits and nearer than that, objects appear confused. These limits are not the same in different people. A good eye can see distinctly when the rays fall parallel upon it; and then the principal focus is at the bottom of the eye.

5. We can judge at a small distance with one eye, by frequently observing how much variation is made in the eye to make the object distinct. But this cannot be done at great distances.

6. But a man can judge of greater distances with both eyes, than he can with one; different distances require different positions of the axes, which depends on the motions of the eyes, and which we feel; in great distances, no judgment

can be made from the motion of the eyes, or their internal parts; we can only guess at the distance from the magnitude, colour, and position of interjacent bodies.

7. Whatever light falls upon that part of the retina, where the optic nerve springs, makes no impression.

SECTION VII.

OF TELESCOPES.

Telescopes are instruments for viewing objects at a great distance; and they may be classed as follows:—

452. *The Refracting Telescope*

Is unfit for many purposes, because the field of view is very small. This inconvenience is, however, remedied by substituting a convex eye-glass; but even there it gives an unpleasant view of terrestrial objects, because it inverts the image with respect to the object.

It does well enough, however, for viewing heavenly bodies, in which no regard is paid to their position, because on account of their rotundity, they do not appear inverted. Every telescope, therefore, for viewing terrestrial objects, should be constructed to show them in their natural position.

453. *The Binocular or Double Telescope.*

Besides the telescope described before, there is also one called a binocular, or double telescope. This is no more than two equal telescopes set in a frame, parallel to one another; and these may be deposited at a proper distance from one another, by the help of screws; but that distance is to be the same as the distance of the two pupils of the eyes. When this adjustment is made, you look through them both at once; through one with each eye, to any object which will then be seen by both eyes, and appear far brighter than through a single telescope.

Telescopes, in general, represent terrestrial objects to be nearer, but not larger; and this nearness, vicinity, or seeming approach of the object, is as the magnifying power of the telescope. Thus looking at a man one hundred yards off, with a telescope that magnifies one hundred times, the man will appear to be no bigger, but will seem only to be a yard off; and the like of other objects situated on the earth.

454. *To find the magnifying power of a Telescope.*

The magnifying power of a telescope will be found if you make two equal circles of paper of an inch or more diameter, and fix one of them upon a wall one hundred or two hundred yards distant; and the other at a small distance, in a line with the first.

Then look at the further circle through the telescope with one eye, and at the near circle with the other eye naked. Move the near circle (or else the telescope) backward and forward, until the two circles appear equal, or coincident. Then measure the two distances, from the eye-glass of the telescope to the two circles; divide the greater distance by the less, and you have the magnifying power of the telescope.

455. *To try the goodness of an Object-Glass.*

There is no better way for trying the goodness of an object-glass than putting it in a tube, and trying it with several small eye-glasses, by looking at several distant objects, and particularly at the title-page of a book; for that glass which represents objects the most bright and distinct, and bears the greatest aperture, and the shortest eye-glass, without colouring or dimness, is the best.

If several telescopes of the same length be compared together, those are the best with which you can read the same print at the greatest distance. And this may be a rule for those that buy telescopes, by which they may know how to choose the best.

456. *The Reflecting Telescope.*

In reflecting telescopes a concave speculum or mirror is substituted for the object-glass, and the eye-glass is so placed as to magnify the image formed by the speculum.

In Dr. Herschel's telescope there is a concave reflector at the bottom of the tube, and the spectator stands with his back to the object, and looks in upon the reflector through the eye-glass.

457. *Acromatic Telescopes*

Are such as have glasses so contrived as to reflect the unequal refraction of the rays of light.

SECTION VIII.

MICROSCOPES.

458. Microscopes are instruments for viewing small objects, and formed upon this principle, that they apparently magnify objects by enabling us to see them nearer, without affecting the distinctness of vision.

The eye brought close to a pin-hole in a sheet of brown paper, will, at the distance of two or three inches, see objects, as letters in a book, apparently magnified, though without the intervention of the paper the letters would at that distance be wholly illegible.

There are three kinds of microscopes, the *single*, the *compound*, and the *solar*, the two former depend wholly on refraction, the latter on reflection as well as refraction.

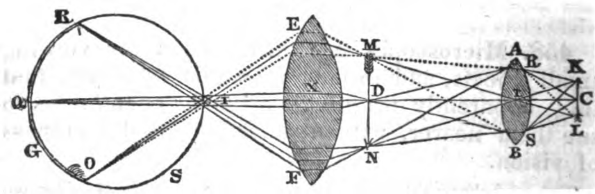
The *single* microscope is a small convex glass, having the object placed in its focus, and the eye at an equal distance on the other side of the glass.

If the object be placed at *a b*, the rays from every point of it will, upon going out of the glass *c d*, be parallel, but the eye being also a convex lens, they will be converged and brought to a focus on the retina where the picture is formed, but in an inverted position.

The magnifying power of this microscope is found by dividing six inches, the distance at which an object can be seen distinctly with the bare eye, by the focal distance, and the quotient will show how much the lens magnifies the diameter of the object.

If the focal distance of the lens be half an inch, or a quarter of an inch, or one-tenth of an inch, then the diameter of the object will be magnified 12 times, or 24 times, or 60 times; and the area of the object will be magnified 144 times, or 576 times, or 3600 times.

459. The compound microscope consists of two lenses, viz. an object-glass which is small and next the object; and an eye-glass, which is larger. In this instrument the distance of the object from the object-glass is somewhat greater than the focal length.



Suppose R Q S, to be the eye, and K L the object placed a little beyond the focus of the lens A B, then the image of the object will be formed at M N, which will be inverted, but the rays of the image flowing through the eye-glass E F, will cross again; an erect image of the object will be formed on the eye, and the object will be seen inverted.

To enlarge the field of vision another and broader lens is often put between the object-glass A B and image M N.

The magnifying power of the compound microscope is in proportion as the image is larger than the object, and also according as we are able to view it at a less distance.

If the image M N be five times larger than the object K L, and by means of the eye-glass we can view it six times nearer than we could by the naked eye, then the instrument will magnify the diameter of the object $5 \times 6 = 30$ times, and the surface 30×30 or 900 times.

460. The solar microscope consists also of two convex lenses enclosed at their proper distances in a brass tube, which is to be fixed in the window shutter of a darkened room. The object is placed between the lenses, and the sun's rays passing through the object-glass, strongly illuminates the object, from which they pass through the second lens and form an inverted image of the object on the opposite wall. And a mirror or looking-glass is used to throw the sun's rays still stronger on the object.

SECTION IX.

OF SPECTACLES.

461. The distance at which a *lens* produces on a wall the representation of an object, is called its *focal* distance; and it is the centre of the circle, of which the surface of the common double lens is a part.

The *concave* lens has the opposite effect; it *diverges* or spreads the rays, instead of *converging* them to a focus.

Hence, when the *eye* is too flat in old age, the convex lens helps its converging powers.

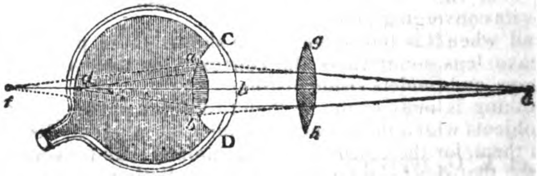
And when it is too convex, as in short-sighted people, the concave lens counteracts the convexity of the eye, spreads the rays, and renders vision distinct.

Nothing is more common, than to observe old people holding objects which they would examine, at a great distance from them, for the reason above-mentioned; and every one knows, that short-sighted people cannot distinguish an object without bringing it very near to their eyes. Both extremes are very inconvenient; but those whose eyes are flat by age, should remember with satisfaction, that they have enjoyed the pleasure of them for many years; and the short-sighted may comfort themselves, that they can distinguish much smaller objects than long-sighted people; for the object is magnified in proportion to the roundness of the eye and the nearness of the focus, and consequently appears four times as big to an eye whose focus is but four inches off, as it does to one whose focal distance is at eight inches. Short-sighted people have also this farther advantage, that age improves their eyes, by the same means that it impairs other people's, that is, by making them more flat.

The nearer any object can be brought to the eye, the larger will be the angle under which it appears, and the more it will be magnified.

Now that distance from the naked eye, where the generality of people are supposed to see small objects best, is about six inches; consequently, when such objects are brought nearer than this measure, they will become less distinct; and if they are brought to four or three inches, they will scarce be seen at all. But by the help of convex glasses, we are enabled to view things clearly at much shorter distances than these: for it is the nature of a convex lens, to render an object distinctly visible to the eye at the distance of its focus; wherefore, the smaller a lens is and the more its convexity, the nearer is its focus and the more its magnifying power.

It is evident that if either the cornea, C *b* D, or the crystalline humour *a b*, or both of them, be too flat, their focus will not be on the retina, as at *d*, where it ought to be, in order to render vision distinct; but beyond the eye, as at *f*. Hence, those rays which flow from the object C, and pass through the humours of the eye, are not converged enough to unite at *d*; and therefore the observer can have but a very indistinct view of the object. This is remedied by placing a convex glass, *gh*, of a proper focus, before the eye; which makes the rays converge sooner, and imprints the image duly on the retina at *d*.



2. If either the cornea or crystalline humour, or both of them, be too convex, the rays that enter in from the object C,

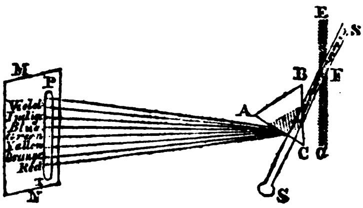
will be converged to a focus in the vitreous humour, as at *f*, and by diverging from thence to the retina, they will thereon form a very confused image; and of course, the observer will have as confused a view of the object, as if his eye had been too flat. This inconvenience is remedied by placing a concave glass, *g h*, before the eye. Now this glass, by causing the rays to diverge between it and the eye, lengthens the focal distance, and therefore if the glass be properly chosen, the rays will unite at the retina, and form upon it a distinct picture of the object.

When glasses are put in frames for spectacles, these frames ought not to be straight, to place both eyes in the same plane; but they should be so bent in the middle, that the axes of both glasses may be directed to one point, at such a distance as you generally look with spectacles. By this means the eyes will fall perpendicular upon both glasses, and make the object appear distinct: but if they fall obliquely upon the glasses, this obliquity will cause a confused appearance in the objects.

SECTION X.

OF COLOURS.

462. Light is not a simple body, but is compounded of seven different kinds, or colours, each of which in passing from one medium to another suffers a different degree of refrangibility.



Let E G, represent a shutter of a room in which no light can enter but through the hole F. If a ray from the sun be admitted through the aperture F, it would form a circular image S, on any screen placed to receive it, but if a triangular piece of glass, A B C, called a prism, be made to intercept the ray, it will not proceed through the glass to *s*, but will be refracted to the screen or wall M N, and form an oblong image, P T, called a spectrum, of different colours, viz. red, orange, yellow, green, blue, indigo, violet. The red is the least refrangible, or the least bent out of the straight line S S; and the violet is the most refrangible.

2. If the whole spectrum be divided into 360 equal parts, the red will be found to occupy 45 of those parts; the orange 27; the yellow 48; the green 60; the blue 60; the indigo 40; and the violet 80.

3. As bodies reflect one or other of these colours, so they are denominated: those that reflect the red rays are called red, and those that reflect the blue are called blue.

4. *White* is a compound of all the seven colours in the proportions mentioned in No. 2.

Experiment. Let a circular board be painted with the seven colours in due proportion, that is, let it be divided into 360 parts, of which 45 are to be painted red; 27 orange; 48 yellow, &c. then turn the board with great velocity; this will produce the effect of mixing the colours, and the whole will appear of a sort of white. If the colours were more perfect the white would be so too.

5. *Black* is an entire deprivation of all the colours, and when an object appears black, the light is completely absorbed.

6. The seven colours are reducible to three, the red, the blue, and the yellow.

7. The most remarkable instance of the natural separation of the primary colours of light is in the rainbow, which is formed by the refraction and reflection of the rays of the sun by drops of rain.

8. There are frequently two rainbows seen at the same time, the one strong and highly vivid, the other weak and ill-defined.

9. The vivid rainbow is occasioned by two refractions and one reflection: the ray of light is refracted in going into the drop, it is reflected to the other side of the drop, and refracted in coming out.

10 The faint bow is occasioned by two refractions and two reflections. To see a rainbow the sun must shine and be at a certain height in the heavens: and the spectator must stand between the sun and the shower.

11. In the vivid rainbow the violet colour will be uppermost, and the red lowermost; and in the faint bow the colours will be reversed.

12. The rainbow will vary in height according to the

height of the sun, for the higher the sun the lower the rainbow: and it is by the constant falling of rain in a shower that the image is preserved constant and perfect.

13. The colour of the sky depends on the vapours in the atmosphere, which, as they are dense or rare, will reflect to the eye the more or less refrangible rays: hence in clear weather we have a blue sky, and when the atmosphere is loaded with vapours we have a dusky whiteness.

463. *Description of the Kaleidoscope, invented by Dr. Brewster.*

The Kaleidoscope (from καλος beautiful, ειδος a form, and σκοπεω to see) is an instrument for creating and exhibiting an infinite variety of beautiful forms, and is constructed in such a manner as either to please the eye, by an ever-varying succession of splendid tints and symmetrical forms, or to enable the observer to render permanent such as may appear most appropriate for any of the numerous branches of the ornamental arts.

This instrument, in its most common form, consists of a tin tube, containing two reflecting surfaces inclined to each other, at any angle which is an aliquot part of 360°. The reflecting surfaces may be two plates of glass, plain or quicksilvered, or two metallic surfaces, from which the light suffers total reflection. The plates should vary in length according to the focal distance of the eye; five, six, seven, eight, nine, and ten inehes will in general be most convenient, or they may be made only one, two, three, or four inches long, provided distinct vision is obtained at one end, by placing at the other end an eye-glass, whose focal length is equal to the length of the reflecting planes. The inclination of the reflectors that is in general most pleasing is 18°, 20°, or 22½°, or the 20th, 18th, and 16th part of a circle, but the planes may be set at any required angle, either by a metallic, a paper, or cloth joint, or any other simple contrivance. When the two planes are put together, with their straightest and smoothest edge in contact, they will have the form shewn in Fig. 1, where A B C is the aperture or angle formed by the plates. In this figure the plates are rectangular, but it may often be more convenient to give them the triangular form, shewn at M, Fig. 2, or N, Fig. 3.

When the instrument is thus constructed, it may be either covered up with paper or leather, or placed in a cylindrical, or any other tube, so that the aperture A B C may be left completely open, and also a small aperture at the angular point D. If the eye is now placed at D, and looks through the aperture A B C, it will perceive a brilliant circle of light, divided into as many sectors as the number of times that the angle of the reflectors is contained in 360°. If this angle is 18°, the number of sectors will be 20°: and, whatever be the form of the aperture A B C, the luminous space seen through the instrument will be a figure produced by the arrangement of twenty of these apertures round C, as a centre, in consequence of the successive reflections between the polished surfaces.

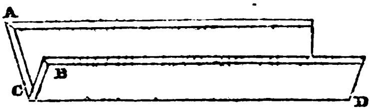


Fig. 1.

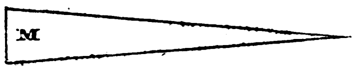


Fig. 2.

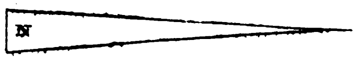


Fig. 3.

Hence it follows, that, if any object, however ugly or irregular in itself, is placed before the aperture A B C, the part of it that can be seen through the aperture will be seen also in every sector, and every image of the object will coalesce into a form mathematically symmetrical, and highly pleasing to the eye. If the object be put in motion, the combination of images will likewise be put in motion, and new forms, perfectly different, but equally symmetrical, will successively present themselves, sometimes vanishing in the centre, sometimes emerging from it, and sometimes playing around in double and opposite oscillations. When the object is tinged with different colours, the most beautiful tints are developed in succession, and the whole figure delights the eye by the perfection of its forms and the brilliancy of its colouring.

The motion of the object may be effected either by the hand or by a simple piece of mechanism, or the same effect may be produced by the motion of the instrument over the object, or round its own axis. In the form of the kaleidoscope now described, the object should be held close to the aperture A B C, and the eye should be placed as nearly as possible in the line C D; for the figure loses its symmetry in proportion as the object recedes from A B C, and as the eye rises above D. The instrument is therefore limited in its present form to the use of objects, which can be held close to the aperture.

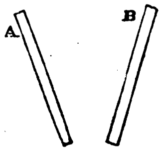
In order to remove the limitation, the tube which contains the reflectors should slide in another tube, of nearly the same length, and having a convex lens at its farther extremity, the focal length of the lens should be always less than its greatest distance from the aperture A B C. In general it should be about one-third or one-fourth of that distance, but it will be advisable to have two or even three lenses of different focal lengths, to fit into the end of the outer tube, and to be used as circumstances may require, or a variation of focal length may be produced by the separation or approach of two lenses. When the instrument is thus fitted up, it may be applied to objects at all distances; and these objects, whose images are formed in an inverted position at the aperture A B C, may be introduced into the symmetrical picture in the very same manner as if they were brought close to the instrument Hence we can introduce trees, flowers, statues, and living animals; and any object which is too large to be comprehended by the aperture A B C may be removed to such a distance that its image is sufficiently reduced.

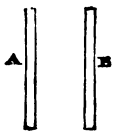
The kaleidoscope is also constructed with three or more reflecting planes, which may be arranged in various ways. The tints placed before the aperture may be the complimentary colours produced by transmitting polarised light through regularly crystallised bodies or pieces of glass that have received the polarising structure. The partial polarisation of the light, by the successive reflections, occasions a partial analysis of the transmitted light; but, in order to develope the tints with brilliancy, the analysis of the light must precede its admission into the aperture.

Instead of looking through the extremity D of the tube, the effects which have been described may be exhibited to many persons at once, upon the principle of the solar microscope or magic-lanthorn; and in this way, or by the application of the camera lucida, the figures may be accurately delineated.

It would be an endless task to point out the various purposes in the ornamental arts to which the kaleidoscope is applicable. It may be sufficient to state, that it will be of great use to architects, ornamental painters, plasterers, jewellers, carvers and gilders, cabinet-makers, wire-workers, book-binders, calico-printers, carpet manufacturers, manufacturers of pottery, and every other profession in which ornamental patterns are required. The painter may introduce the very colours which he is to use, the jeweller the jewels which he is to arrange, and in general the artist may apply to the instrument the materials which he is to embody, and thus form the most correct opinion of their effect when combined into an ornamental pattern. When the instrument is thus applied, an infinity of patterns is created, and the artist can select such as he considers most suitable to his work. When a knowledge of the nature and powers of the instrument has been acquired by a little practice, he will be able to give any character to the pattern that he chooses, and he may even create a series of different patterns, all rising out of one another, and returning by similar gradations to the first pattern of the series.

In all these cases the pattern is perfectly symmetrical round a centre, or all the images of the aperture A B C are exactly alike, but this symmetry may be altered, for after the pattern is drawn it may be reduced into a square, a triangular, an elliptical, or any other form that he pleases. The instrument will give annular patterns, by keeping the reflectors separate, as at A B, fig. 4, and it will give rectilineal ones, by placing the reflectors parallel to each other, as in fig. 5.





The kaleidoscope is also an instrument of amusement, to please the eye, by the creation and exhibition of beautiful forms, in the same manner as the ear is delighted by the combination of musical sounds. When Custillon proposed the construction of an ocular harpsichord, he was mistaken in supposing that any combination of harmonic colours could afford pleasure to the person who viewed them; for it is only when these colours are connected with regular and beautiful forms that the eye is gratified by the combination. The kaleidoscope, therefore, seems to realise the idea of an ocular harpsichord.

CHAPTER XIII.

OPERATIONS IN THE MECHANICAL ARTS.

SECTION I.

OF CEMENTS.

464. CEMENTS are of various compositions, according to the substances to which they are applied, and their exposure to heat and moisture.

465. *Common Glue.* Common glue is formed by extracting the gelatinous part of cuttings or scraps of coarse leather, or the hides of beasts: it is never manufactured but in a large way.

466. *Isinglass glue.* Isinglass glue is made by dissolving beaten isinglass in water by boiling, having strained it through a coarse linen cloth, it evaporates again to such a consistence, that being cold, the glue will be hard and dry.

This cement is improved by dissolving the isinglass in proof spirit by heat, or by adding to it, when dissolved in water, an equal quantity of spirits of wine.

It is still further improved, by adding to the isinglass, previous to its solution in spirits, one third of its weight of gum ammoniac. Expose the mixture to a boiling heat until the isinglass and gum are dissolved, and until a drop of the composition, becomes instantly stiff as it cools. It will in future melt with a degree of heat little exceeding that of the human body, and, in consequence of becoming stiff in cooling, forms a valuable cement for fixing on the antennæ, &c. of insects in the cabinet of natural history. The easy melting of this cement is no objection to its use, for it owes this property only to the presence of the spirit which evaporates soon after it has been applied. When used to join broken glass or china, the pieces should be previously warmed, and immersion in hot water will give them a sufficient degree of heat. Wipe off the water before applying the cement, which may be laid on with a pencil; then press the pieces together, binding them with a string or a bit of soft wire, if necessary.

For nice purposes, this isinglass glue is preferable to common glue, being stronger, and less liable to soften by heat or moisture.

467. *Parchment glue* is made of one pound of shreds of parchment, or vellum boiled in six quarts of water, till the quantity be reduced to one quart, the fluid is strained off from the dregs, and then boiled again till it be of the consistence of glue.

Glovers' cuttings of leather, dressed with alum, instead of being tanned, makes a colourless glue.

468. *To make sign board glue.* Melt common glue with water to a proper consistence; add one-eighth of boiled linseed oil, dropping it gently into the glue, which is to be kept stirring all the time.

A strong glue is made by adding some powdered chalk to common glue, and another that will resist water by adding half a pound of common glue to two quarts of skimmed milk.

469. *To prepare lip glue for cementing paper, &c.* Take of isinglass and parchment glue, each one ounce; of sugar-candy, and gum tragacanth, each two drachms; add to them an ounce of water, boil the whole, till the mixture appears, when cold, of the consistence of glue. Then form it into small rolls for use.

This glue wetted with the tongue, and rubbed on the edges of the paper, silk, &c. to be cemented, will, on their being laid together, and suffered to dry, unite them as firmly as any other part of the surface.

470. *Lapland glue.* Laplander's bows are composed of two pieces of wood glued together; one of them of birch, which is flexible, and the other of fir of the marshes, which is stiff, in order that the bow when bent may not break, and that when unbent it may not bend. When these two pieces of wood are bent, all the points of contact endeavour to disunite themselves, and to prevent that, the Laplanders employ the following cement.

They take the skins of large perches, and having dried them, moisten them in cold water until they are so soft that they may be freed from the scales, which are thrown away, probably eel skins would answer the same purpose. They then put four or five of these skins into a rein-deer's bladder, or they wrap them up in a soft bark of the birch tree, in such a manner, that water cannot touch them, and place them thus covered into a pot of boiling water, with a stone above them to keep them at the bottom. When they have boiled about an hour, they take them from the bladder or bark, and they are then found to be soft and viscous. In this state they employ them for glueing together the two pieces of wood which compose their bows, and which they strongly compress and tie up till the glue is well dried. These pieces never after separate.

471. *Cheese glue.* Take skimmed-milk cheese, freed from the rind, cut it into slices, boil it in water, stirring it with a spoon until it be reduced to a strong glue, which does not incorporate with water; then throw away the hot water; pour cold water over the glue, and knead it afterwards in warm water, subjecting it to the same process several times. Put the warm glue on a grinding stone, and knead it with quick-lime until you have a good glue.

To use this glue you must warm it; employed cold it is not so strong, but it may be used in that manner. This glue is insoluble in water as soon as it is dry, and it becomes so in forty-eight hours after it has been applied. It may be used for gluing wood, cementing marble and broken earthenware. Baits for catching fish may also be made of it. Fish are very fond of it, and it resists water.

472. *Jeweller's cement.* In setting precious stones, pieces are sometimes broken off by accident, but these may be joined so correctly, that an inexperienced eye would not discover the stone to have been broken.

Jewellers employ for this purpose a small piece of gum mastich applied between the fragments, which are previously heated sufficiently to enable them to melt the interposed gum. They are then pressed together, to force out the redundant gum.

473. *Turkey cement, for joining metals, glass, &c.*

Dissolve six bits of mastich, as large as peas, in as much spirits of wine as will suffice to liquify; in another vessel dissolve as much isinglass (which has been previously soaked in water till it has swollen and is soft), in brandy or rum, as will make two ounces by measure of strong glue, and add two small bits of gum galbanum, or ammoniacum, which must be rubbed till they are dissolved; then mix the whole with a sufficient heat; keep it in a phial stopt, and when used set it in hot water.

474. *Broken china cement.* Take quick-lime and white of eggs, or old thick varnish; grind and temper them well, and it will be ready for use.

Drying oil and white lead are used for cementing china and earthen-ware; but this cement requires a long time to dry. Where the vessels are not to endure heat or moisture, isinglass glue, with a little tripoli, or chalk, is better; the juice of garlic also forms a strong cement, and the joining cannot easily be perceived.

475. *Chemical glasses' cement.* In the whites of eggs mix equal quantities of wheat flour, fine powdered Venice glass, pulverized chalk, with half the quantity of fine brick-dust, and a little scraped lint. This mixture is spread upon a linen cloth, and applied to the crack of the glasses; it should be dried before they are put to the fire.

476. *Turner's cement.* Melt together resin one pound, pitch four ounces: and, while boiling hot, add brick dust, until, by dropping a little upon a stone, you perceive it hard enough; then pour it into water, and immediately make it up in rolls, and it is fit for use.

Another, finer. Take resin one ounce, pitch two ounces; add red ochre, finely powdered, until you perceive it strong enough. Sometimes a small quantity of tallow is used, according to the heat of the weather, more being necessary in winter than summer.

Either of these cements is of excellent use for turners. By applying it to the side of a chuck, and making it warm before the fire, you may fasten any thin piece of wood, which will hold fast while you turn it; when you want it off again strike it on the top with your tool, and it will drop off immediately.

477. *Electrical cement.* Melt in a pot, over a slow fire, one pound of resin; add as much plaster of Paris, in fine powder, as will make it hard enough, which you may know by trial; then add a spoonful of linseed oil, stirring it all the while, and try if it be hard and tough enough for your purpose; if it is not sufficiently hard, add more plaster of Paris; and if not tough enough, a little more linseed oil.

This is for fixing the necks of globes or cylinders, or any thing that requires to be strongly cemented, for it is not easily melted when cold.

Another, softer. Take resin one pound, bees-wax one ounce; add as much red ochre as will make it sufficiently stiff; pour it into water, and make into rolls for use. This cement is for cementing hoops on glasses, or any other mounting of electrical apparatus.

478. *Glass grinder's cement.* Boil pitch, adding thereto, fine sifted wood ashes, until you have it of a proper temper, stirring it all the while; a little tallow may be added, as you find necessary.

Another, for small work. To four ounces of resin add one-fourth of an ounce of bees-wax, melt them together, adding four ounces of whitening made previously red hot. The whitening should be put while hot, that it may not have time to imbibe moisture from the atmosphere.

Shell-lac is a strong cement for metals, glass, or precious stones, while cutting, twining, or grinding them. The metal, &c. should be warm to melt it. Shell-lac is excellent for fastening ruby cylinders in watches, and similar delicate purposes.

479. *Broken glass solder.* Broken glass is soldered by interposing between the parts, glass ground up like a pigment, but of easier fusion than the pieces to be joined, and then exposing them to such a heat as will fuse the cementing ingredient, and make the pieces agglutinate without being themselves fused.

A glass for cementing broken pieces of flint glass may be made by fusing some of the same kind of glass previously reduced to powder, with a little lead and borax, or with borax only.

480. *Derbyshire spar cement, &c.* This cement is made with about eight parts of resin and one of bees wax, melted together with a small quantity of plaster of Paris. If the cement is to fill up the place of any small chips that may have been lost, the quantity of plaster may be encreased a little. When the ingredients are well mixed, and the whole nearly cold, the mass must be well kneaded together. The pieces of spar to be joined, must be heated until they melt the cement, and then pressed together, some of the cement being previously interposed.

Melted sulphur applied to fragments of stones previously heated (by placing them before a fire) to at least the melting point of sulphur, and then joined with the sulphur between makes a pretty firm and durable joining.

Little deficiencies in the stone, as chips out of corners, &c. may also be filled up with melted sulphur, in which some of the powder of the stone has been melted.

481. *Steam cement.* To join the flanches of iron cylinders, and other parts of hydraulic and steam engines, the following methods are adopted by machinists:

Boiled linseed-oil, litharge, red and white-lead mixed together to a proper consistence, applied on each side of a piece of flannel previously shaped to fit the joint, and then interposed between the pieces before they are brought home (as the workmen term it) to their place by the screws or other fastenings employed, make a close and durable joint.

The quantities of the ingredients may be varied without inconvenience, taking care not to make the mass too thin with oil. It is difficult in many cases instantly to make a good fitting of large pieces of iron work. This renders it necessary sometimes to join and separate the pieces repeatedly, before a proper adjustment is obtained. When this is expected, the white lead ought to predominate in the mixture, as it dries much slower than the red. A workman knowing this fact, can be at little loss in exercising his own discretion in regulating the quantities. It is safest to err on the side of the white-lead, as the durability of the cement is not thereby effected, a longer time only is required for it to dry and harden.

When the fittings will not easily admit of so thick a substance as flannel being interposed, linen may be substituted, or even paper or thin paste-board.

This cement answers well also for joining broken stones, however large. Cisterns built of square stones, put together with this cement, will never leak, or want any repairs. In this case the stones need not be entirely bedded in it: an inch, or even less, of the edges that are to be next the water, need only be so treated; the rest of the joint may be filled with good lime.

482. *Another of the same.* This cement, preferable even to the former, for steam-engines, is prepared thus:

Take two ounces of sal ammoniac, one ounce of flowers of sulphur, and sixteen ounces of cast iron filings or borings; mix them in a mortar, and keep the powder dry.

When the cement is wanted for use, take one part of the above powder, and twenty parts of clean iron borings or filings, and blend them intimately by grinding them in a mortar. Wet the compound with water, and when brought to a convenient consistence, apply it to the joints with a wooden or blunt iron spatula. This is the cement with which the joinings of the Southwark cast iron bridge were filled up and clasped. Action and reaction take place among the ingredients, and between them and the iron surfaces, which at last causes the whole to unite as one mass. After a time, the surfaces and the mixture become one.

483. *Blood cements* are used by coppersmiths to lay over the rivets and edges of the sheets of copper in boilers of the first class; they also give additional security to the joinings, and secure cocks from leaking

This cement is made by mixing pounded quick lime with oxen's blood: but unless used when fresh made, it will become hard. It is durable, cheap, and extensively applicable in the rougher branches of art.

484. *Flour paste cement.* Flour paste for cementing, is formed principally of wheaten flour, boil-

ed in water till it be of a glutinous or viscid consistence.

It may be prepared of these ingredients simply for common purposes, but when it is used by book-binders, or for paper hangings, it is usual to mix with the flour a fifth or sixth of its weight of powdered alum; and where it is wanted still more tenacious, gum arabic, or any kind of size, may be added.

485. *Rice glue.* This elegant cement is made by mixing rice-flour intimately with cold water, and then gently boiling it. It is beautifully white, and dries almost transparent. Papers pasted together with this cement will sooner separate in their own substance than at the joining, it is therefore extremely useful in the preparation of curious paper articles, as tea trays, ladies' dressing and work boxes, and other articles which require layers of paper to be cemented together. In every respect it is preferable to common paste made with wheat flour. It answers well for pasting into books the copies of writings taken off by copying machines on unsized silver paper.

With this composition, made with a small quantity of water, that it may have a consistence similar to plastic clay, models, busts, statues, basso relievos, and the like, may be formed. When dry, the articles made of it are susceptible of a high polish; they are also very durable.

The Japanese make quadrille fish of this substance, which so nearly resemble those made of mother of pearl, that the officers of our East Indiamen are often imposed upon.

486. *Of Sizes.* Common size, manufactured in the same manner, and generally by the same people, as glue, is glue left in a moister state, by discontinuing the evaporation before it is brought to a dry consistence.

487. *Isinglass size* is prepared much in the same way as glue; the quantity of water for dissolving it is increased; and the same makes good parchment size.

SECTION II.

OF JAPANNING.

488. Japanning is the art of varnishing and painting ornaments on wood, as is done by the natives of the island of Japan.

All substances that are dry and rigid, or not too flexible; as wood, metals, leather, and paper prepared; admit of being japanned.

Wood and metals require no other preparation than to have their surfaces perfectly even and clean; but leather should be securely stretched, either on frames or on boards; as its bending would crack, and force off the varnish. Paper should be treated in the same manner, and have a previous strong coat of size; but it is rarely japanned, till converted into *papier machié*, or wrought into such form, that its flexibility is lost.

489. *Of japan grounds.* When a priming is used, the work should be well smoothed with fish-skin or glass-paper, and being made thoroughly clean, brushed over once or twice with hot size, diluted with two thirds water, if it is of the common strength. The priming is laid on as even as possible. It is a size, of a consistency between the common kind and glue, mixed with as much whiting as will give it a sufficient body of colour to hide the surface of whatever it is laid upon. This is repeated till the inequalities are filled up, then the work is cleaned off with Dutch rushes, and polished with a wet rag.

When wood or leather is japanned, and no priming used, the best preparation is to lay on two or three coats of coarse varnish, composed in the following manner:

Take one pint of rectified spirits of wine, and of coarse seed-lac and resin, each two ounces; dissolve the seed-lac and resin in the spirit, and then strain off the varnish.

This varnish, like all others formed of spirit of wine, must be laid on in a warm place; and if it can be conveniently managed, the piece of work to be varnished should also be made warm; for the same reason, all dampness should be avoided; as cold or moisture chills this varnish, and prevents its taking hold of the substance on which it is laid.

When the work is so prepared, or by the priming with the composition of size and whiting above described, the proper japan ground must be laid on. This is best formed of shell-lac varnish, and the colour desired, except white, which requires a peculiar treatment; and if brightness be wanted, other means must be pursued.

The colours used with the shell-lac varnish may be any pigments, which give the tint of the ground desired.

As metals never require to be under-coated with whiting, they are treated in the same manner as wood or leather.

490. *White Japan grounds.* The nearest approach, to a perfect white varnish, already known, is made by the following composition.

Take flake-white, or white lead, washed over and ground up with one sixth of its weight of starch and then dried; temper it properly for spreading with mastich varnish; and lay these on the substance to be japanned, prepared either with or without the under coat of whiting, as ordered above; and then varnish it over with five or six coats of the following varnish.

From a quantity of the best seed-lac, pick out all the clearest and whitest grains, reserving the more coloured and fouler parts for the coarse varnishes, such as that used for priming or preparing wood or leather. Take of this picked lac two ounces, and of gum animi three ounces; reduce them to a gross powder, and dissolve them, in about a quart of spirits of wine, and strain off the clear varnish.

The seed-lac will give a slight tinge to this composition; but it cannot be avoided, when hard varnish is wanted; though, when a softer will answer the end, the proportion may be diminished, and a little crude turpentine added to the gum animi to take off the brittleness.

A very good varnish, entirely free from brittleness, may be formed by dissolving as much gum animi as the oil will take, in old nut or poppy oil. This must be boiled gently when the gum is put into it. The ground of white colour itself is laid on in this varnish, and then a coat or two of it put over the ground; but when used, it must be well diluted with oil of turpentine. This, though free from brittleness, is liable to suffer by being indented or bruised by any slight strokes; and it will not bear any polish, but may be brought to a smooth surface without, if judiciously managed in the laying it on. It is tedious drying and requires time where several coats are laid on; as the last should be without oil of turpentine.

491. *Blue japan grounds.* Blue japan grounds are formed of bright Prussian-blue; or of verditer, glazed over by Prussian-blue, or smalt.

The colour is best mixed with shell-lac varnish, and brought to a polishing state by five coats of varnish of seed-lac; but the varnish will somewhat injure the colour, by giving a cast of green to a true blue, and fouling a warm blue by the yellow it contains; where a bright blue is required, and a less degree of hardness can be dispensed with, we pursue the method directed in the case of white grounds.

492. *Red japan grounds.* For a scarlet japan ground, vermillion is used; but it has a glaring effect, much less beautiful than the crimson produced by glazing it over with carmine, *fine lake,* or rose pink.

For a bright crimson, instead of glazing with carmine, use Indian lake, dissolved in the spilet of which the varnish is compounded; in this case, instead of glazing with the shell-lac varnish, the polishing coats are only used, as they equally receive and convey the tinge of the Indian-lake, which may be dissolved by spirits of wine; but if the highest degree of whiteness is required, use the white varnish.

493. *Yellow japan grounds.* For bright yellow grounds, employ King's yellow, or turpeth mineral, either alone or mixed with fine Dutch-pink. The effect may be heightened, by dissolving turmeric root in the spirits of wine, of which the upper or polishing coat is made. The spirits of wine must be strained from off the dregs before the seed-lac beadded to it, to form the varnish.

The seed-lac varnish is not equally injurious here, and with greens; because, tinged with a reddish yellow only, it is little more an addition to the depth of colour.

Yellow grounds may be found of Dutch-pink only, which, when good, is not deficient in brightness, though extremely cheap.

494. *Green japan grounds.* Green grounds are prepared by mixing King's-yellow and Prussian-blue, or turpeth mineral and Prussian-blue. And a cheap, but fouler kind by verdigris, with a little of the above-mentioned yellows, or Dutch-pink. Where a bright green is wanted, the crystal of verdigris, (distilled verdigris,) are employed; to heighten the effect, they are laid on a ground of leaf-gold, when the colour is extremely brilliant and pleasing.

495. *Orange japan grounds.* Orange coloured japan grounds are formed by mixing vermillion, or red lead, with King's yellow, or Dutch pink, or the orange lake, which will make the brightest orange ground that can be produced.

496. *Purple japan grounds.* Purple japan grounds are produced by the mixture of lake and Prussian-blue; of a darker hue, by vermillion and Prussian-blue. With respect to the varnish they are treated as the others.

497. *Black japan grounds formed without heat.* Black grounds may be formed by ivory black, or by lamp-black; the former is preferable when good. These are laid on with shell-lac varnish; and have their upper or polishing coats of common seed-lac varnish, the tinge of the varnish being no injury here.

498. *Common black japan grounds on iron or copper, formed by heat.* To form black japan grounds by heat, the work to be japanned is painted over with drying oil, and lamp-black; when of a moderate dryness, it must be exposed to such a heat, as will change the oil to black, without weaken-

ing its tenacity. The stove should not be too hot when the work is put into it, nor the heat increased too fast, else it will blister; the slower the heat is augmented, and the longer it is continued, provided it be restrained within the due degrees, the harder will be the japan. This kind of varnish requires no polish, as that which it receives from the heat when properly managed is sufficient.

499. *Tortoise-shell japan ground, formed by heat.* The best tortoise-shell ground produced by heat is valuable for its great hardness, and its beautiful appearance. Besides it endures to be made hotter than boiling water without damage. It is made by means of a varnish prepared thus:

Take one gallon of good linseed-oil, and of umber half a pound; boil them together till the oil becomes brown and thick; strain it through a coarse cloth, and boil it again, till it acquire a pitchy consistence, when it will be fit for use.

Having prepared the varnish, clean well the iron or copper plate, or other pieces which are to be japanned, then lay vermillion tempered with shell-lac varnish, or with drying oil diluted with oil of turpentine, very thinly, on the plates intended to imitate the more transparent parts of the tortoise-shell. When the vermillion is dry, brush the whole over with the black varnish, to a true consistence with oil of turpentine; and when it is set and firm, put the work into a stove, where it may undergo a very strong heat, for three weeks or a month, the longer the better.

This ground may be decorated with painting and gilding as other varnished surfaces. This is done after the ground has been hardened by the stove; but it should receive a second annealing with a more gentle heat, after it is finished,

500. *The method of painting japan-work.* Japan work should be painted with colours in varnish; though for dispatch, and in nice work where the freer use of the pencil is required, the colours are tempered in oil. But the oil should previously have a fourth part of its weight of gum animi; or, gum sandarach, or gum mastich dissolved in it. When the oil is thus used, it is diluted with oil of turpentine, for the colours to lay evenly and thin. By this

means, fewer of the polishing or upper coats of varnish become necessary.

Water colours are in some instances laid on grounds of gold. These are best, when so used in their proper appearance, without any varnish over them; and they are also sometimes managed to have the effect of embossed work. The colours thus employed, for painting, are prepared with isinglass size, corrected by honey or sugar-candy. The body of the embossed work which is raised, is not tinged with the exterior colour, but formed of strong gum water, thickened to a proper consistence by equal parts of cole Armenian and whiting. This gum is laid on the proper figure, and repaired when dry, and the whole may be then painted with the proper colours, tempered with the isinglass size, or, shell-lac varnish.

501. *The manner of varnishing japan work.* The finishing of japan work consists in the laying on and polishing, the outer coats of varnish, as well in the pieces that have only one simple ground of colour, as those that are painted. This is done with common seed-lac varnish, except where other methods are now expedient. The same reasons which decide as to the fitness of the varnishes, with respect to the colours of the ground, hold equally with regard to those of the painting. Where brightness is the most material point, and a tinge of yellow will injure it, seed-lac gives way to the whiter gums; but where hardness, and a greater tenacity, are essential, the seed-lac must be adhered to, where both are so necessary, that reciprocally one should give way to the other, it is usual to adopt a mixed varnish.

This mixed varnish is made of the picked seed-lac. The common seed-lac varnish, the most useful preparation of the kind, may be thus made.

Take three ounces of seed-lac, put it into water, to free it from the sticks and filth intermixed with it. To do this stir it about, and then pour off the water, adding fresh quantities, till it be freed from all impurities. Then dry it, powder it grossly, and put it, with a pint of rectified spirit of wine, into a bottle, of which it will not fill above two-thirds. Shake the mixture, place the bottle in a gentle heat, till the seed-lac be dissolved; in the mean time repeat the shaking, then pour off all that can be obtained clear, strain the remainder through a coarse cloth and the varnish thus prepared is kept for use in a well-stopped bottle.

In using the seed-lac, (or white varnish,) the substance used in polishing, should be itself white, where a pure white of a great clearness is desired; whereas the browner sorts of polishing-dust, are cheaper, and may be used in other cases with greater dispatch. The work to be varnished, is placed near a fire, or stove, and made perfectly dry; the varnish is then rubbed over it by the brushes made for that purpose, beginning in the middle, and passing the brush to one end, and then with another stroke from the middle, passing to the other. Where it can be possibly avoided no part should be crossed, or twice passed over, in forming one coat. When one coat is dry, another is laid over it; and this process is continued at least six times, or more, if, on trial, the varnish be not sufficiently thick to bear the polish, without laying bare colour underneath.

When a sufficient number of coats have been thus laid on the work it is fit to be polished. In common cases, this is done, by rubbing it with a rag, dipped in tripoli, or rotten-stone, finely powdered; but, towards the end of the rubbing, a little oil of any kind is used with the powder; when the work is sufficiently bright and glossy, it is rubbed with oil alone, to clean it from the powder, and give a brighter lustre.

In the case of white grounds, instead of tripoli, or rotten-stone, fine putty, or whiting, is used; both of which are washed over, to prevent the danger of damaging the work, from sand or gritty matter with which they may happen to be mixed.

It is an improvement in japan-work, to harden the varnish by heat; which in every degree that it can be applied, short of what would burn or calcine the matter, gives it a firmer and stronger texture.

Where metal forms the body, a hot stove is used; and the process of work are continued in it a considerable time, especially if the heat be gradually encreased; but where the work is of wood, heat is sparingly used, as it is liable to warp or shrink the body, and injure its general figure.

SECTION III.

OF VARNISHING.

502. Varnish is a clear limpid fluid, which hardens, without losing its transparency. It is used by painters, gilders, &c. give a lustre to their works, and to preserve and defend them from the air and moisture.

A coat of varnish ought to possess the following properties:

1. It must exclude the action of the air; because wood and metals are varnished to defend them from decay and rust.

2. It must resist water; else the effect of the varnish could not be permanent.

3. It ought not to alter the colours it is intended to preserve. It is necessary, therefore, that every varnish should be easily spread over the surface, without leaving pores or cavities, that it should not crack or scale, and that it should resist water.

Resins are the only bodies that possess these properties; they must therefore form the basis of every varnish. For this purpose, they must be dissolved, as minutely divided as possible, and combined so that the imperfections of those that might be disposed to scale may be corrected by others.

Resins may be dissolved by three agents; 1. by fixed or fat oil; 2. by volatile, or essential oil; 3. by spirit of wine. Accordingly we have three kinds of varnish; *fat*, or *oily varnish*; *essential varnish*, and *spirit varnish*.

And these agents are of such a nature as either to dry up and become hard, or else to evaporate and fly off, leaving the resin fixed behind.

Varnishes should be carefully kept from dust, and in very clean vessels: they should be laid thin and even with a large flat brush, the strokes being drawn all one way. A warm room does best for varnishing in, cold chills the varnish and prevents it from laying even,

Varnishes are *polished* with pumice-stone and tripoli. The pumice-stone reduced to a fine powder, is put upon a piece of serge moistened with water;

and with this the varnished substance is rubbed equally and lightly. The tripoli also reduced to a fine powder, is put upon a clean woollen cloth moistened with olive oil, with which the polishing is performed. The varnish is then wiped with soft linen, and when dry, cleaned with starch, or Spanish white, and rubbed with the palm of the hand, or a linen cloth.

503. *Fat oil varnish.* Fixed, or fat oil, does not evaporate; nor become dry of itself. And therefore to make it dry, it is boiled with metallic oxydes. Litharge is generally used for this purpose. Oil so prepared, is called *drying-oil.* But to accelerate the drying of oil-varnish, we add oil of turpentine.

Gum-copal, and *amber*, are the substances chiefly employed in oil varnishes; the copal is white, and used for varnishing light, the amber for dark colours.

Before mixing them with the oil, it is best to dissolve them; because they are then in less danger of being scorched, the varnish is also more beautiful. They should be melted in an iron-pot; they are in a proper state for receiving the oil when they offer no resistance to the iron *spatula*, and run off from it drop by drop.

To make oil varnish, pour by little and little, six or eight ounces of drying-oil among sixteen ounces of melted copal, or amber, constantly stirring the ingredients with the spatula. When the oil is well mixed with the copal or amber, take it off the fire; and when nearly cool, put in sixteen ounces of the essence of Venice turpentine. The varnish should be passed through a linen cloth.

Oil varnishes become thick by keeping; when they are to be used, it is only necessary to pour in a little Venice turpentine, and to put them a short time on the fire. Less turpentine is necessary in summer than winter; too much oil hinders the varnish from drying; when too little is used, it cracks, and does not spread properly.

504. *Black varnish for coaches and iron-work.* This varnish is composed of asphaltum, resin, and amber,

melted separately, and afterwards mixed; the oil is then added, and afterwards the turpentine, as directed above. The proportions are, twelve ounces of amber, two of resin, two of asphaltum, six of oil, and twelve of turpentine.

505. *A varnish for rendering silk impenetrable to water and air.* To render linseed-oil drying, boil it with two ounces of sugar of lead, and three ounces of litharge, for every pint of oil, till the oil has dissolved them; then put a pound of bird-lime, and half a pint of the drying-oil, into an iron or copper pot, holding about a gallon; and let it boil gently over a slow charcoal fire, till the bird-lime ceases to crackle; then pour upon it two pints and a half of drying-oil, and boil it for about an hour longer, stirring it often with an iron or wooden spatula.

As in boiling, the varnish swells much, the pot should be removed from the fire, and replaced when the varnish subsides. While it is boiling, it should be occasionally examined, to determine whether it has boiled enough. For this purpose take some of it upon the blade of a large knife, and after rubbing the blade of another knife upon it, separate the knives; and when, on their separation, the varnish forms threads between the two knives, it has boiled enough, and should be removed from the fire. When it is almost cold, add about an equal quantity of spirits of turpentine; mix both well together, and let the mass rest till the next day; then having warmed it a little, strain and bottle it. If it is too thick, spirits of turpentine. This varnish should be laid up in the stuff when perfectly dry, in a lukewarm state; a thin coat of it upon one side, and about twelve hours after, two other coats should be laid on, one on each side; and in twenty-four hours the silk may be used.

506. *Blanchard's air-balloon varnish.* Dissolve elastic gum (Indian-rubber,) cut small, in five times its weight of spirits of turpentine, by keeping them some days together; then boil one ounce of this solution in eight ounces of drying linseed-oil for a few minutes, and strain it: use it warm.

507. *Essential oil varnish.* The essential varnishes consist of a solution of resin in oil of tur-

pentine. This varnish being applied, the turpentine evaporates, leaving the resin behind. They are commonly used for pictures.

508. *To dissolve gum-copal in oil of turpentine.* The quantity to be dissolved, should be put into a glass vessel capable of containing at least four times that quantity, and it should be high in proportion to its breadth.

Reduce two ounces of copal to small pieces, put them into a proper vessel. Mix a pint of oil of turpentine with one-eighth its quantity of spirit of sal ammoniac; shake them well together; put them to the copal; cork the glass, and tie it over with a string or wire, making a small hole through the cork. Set the glass in a sand heat so regulated, as to make the contents boil as quickly as possible, but so gently, that the air bubbles may be counted as they rise from the bottom. The same heat must be kept up till the solution is complete.

It requires accurate attention to succeed in this operation. After the spirits are mixed, they should be put to the copal, and the necessary degree of heat given as soon as possible. It should likewise be kept up with the utmost regularity. If the heat abates, or the spirits boil quicker than is necessary, the solution will immediately stop, and with the same materials will afterwards be in vain to proceed; but if properly managed, the sal ammoniac spirit will gradually descend from the mixture, and attack the copal, which will swell and dissolve, except a very small quantity that will remain undissolved.

The vessel should not be opened till some time after it has cooled, as it has happened that on uncorking the vessel, when it was not warm enough to affect the hand, that the contents have been blown against the ceiling. The spirit of turpentine should be of the best quality had from Apothecaries Hall.

This varnish, a rich deep colour in the bottle, gives no colour to the pictures it is laid on. If left in the damp, it remains tacky, a long time; but in a warm room, or the sun, it dries as other turpentine varnishes.

509. *Spirit varnishes.* When resins are dissolved in alkohol (spirits of wine,) the varnish dries speedily,

but cracks. This fault is corrected by adding a small quantity of oil of turpentine, which renders it brighter, and less brittle when dry.

510. *To dissolve gum-copal in spirits of wine.* Dissolve half an ounce of camphor in a pint of alkohol, put it into a circulating glass, add four ounces of copal, in small pieces; set it in a sand-heat so regulated, that the air bubbles may be counted as they rise from the bottom; and continue the same heat till the solution is completed.

Camphor acts more powerfully upon copal than any other substance. If copal finely powdered, be rubbed with a small quantity of dry camphor in the mortar, the whole becomes in a few minutes a tough coherent mass. The most economical method is to set the vessel which contains the solution by for a few days; and when perfectly settled, pour off the clear varnish, and leave the residuum for a future operation.

This is a very bright solution of copal, and an excellent varnish for pictures, besides being an improvement in fine japan works, as the stoves used in drying those articles may drive off the camphor entirely, and leave the copal pure and colourless upon the work.

Copal dissolves in spirit of turpentine, by the addition of camphor, with the same facility, but not in the same quantity, as in alkohol.

511. *A varnish for wainscot, cane chairs, &c.* Dissolve in a quart of spirits of wine, eight ounces of gum-sandarach, two ounces of seed-lac, and four ounces of resin; then add six ounces of Venice-turpentine. If the varnish is to produce a red colour, more of the lac and less of sandarach should be used, and a little dragon's-blood should be added. This varnish is very strong.

512. *A varnish for toilet-boxes, cases, fans, &c.* Dissolve two ounces of gum-mastich, and eight ounces of gum sandarach, in a quart of alkohol; then add four ounces of Venice-turpentine.

513. *A varnish for violins, and other musical instruments.* Put four ounces of gum-sandarach, two ounces of lac, one ounce of gum-elemi, into a quart of alkohol, and hang them over a slow fire till they

are dissolved; then add two ounces of turpentine.

514. *Varnish for employing vermillion for painting equipages.* In a quart of alkohol dissolve six ounces of the sandarach, three ounces of gum-lac, and four ounces of resin; add six ounces of the cheapest kind of turpentine afterwards: mix it with a proper quantity of vermillion when used.

515. *Seed-lac varnish.* Put one quart of spirits of wine, in a wide mouthed bottle, add eight ounces of seed-lac, clear and free from dirt; let it stand two days, or longer, in a warm place, shaking it often. Strain it through a flannel into another bottle, and it will be fit for use.

516. *Shell-lac varnish.* Take one quart of spirits of wine, eight ounces of thin transparent shell-lac, which, if melted in the flame of a candle, will draw out in fine long hair; mix and shake these together, and let them stand in a warm place for two days, and it will be ready for use. This varnish is softer than that made from seed-lac, and not so useful; but may be mixed with it for varnishing wood, &c.

517. *White varnish for clock faces, &c.* Take of highly rectified spirits of wine one pint, which divide into four parts; then mix one part with half an ounce of gum-mastich, in a phial, one part of spirits, and half an ounce of gum-sandarach in another phial; one part of spirits, and half an ounce of the whitest parts of gum-benjamin. Then mix and temper them to your mind, and it may not be amiss to add a little bit of white resin, ochre, Venice-turpentine, in the mastich bottle; to give a gloss.

If your varnish be strong and thick, add spirits of wine only; if hard, some dissolved mastich; if soft, some sandarach or benjamin. When you have brought it to a proper temper, warm the silvered plate before the fire (if a clock face, taking care not to melt the wax,) and with a flat camel's-hair pencil, stroke it all over until no white streaks appear, and this will preserve silvering many years.

SECTION IV.

OF LAQUERING.

518. *Laquering* is the laying on metals, coloured or transparent varnishes, to produce the appearance of a different colour in the metal, or to preserve it from rust.

Laquering is employed where brass receives the appearance of being gilt; where tin is made to assume the resemblance of yellow metals; and where brass work is to be protected against the corrosion of the air or moisture.

Seed-lac is the principal substance used for the composition of laquers; but for coarser purposes, resin or turpentine is added, to make the laquer cheaper.

519. *A laquer for brass, to imitate gilding.* Take one ounce of turmeric, add of saffron and Spanish-arnotto, each two drachms. Put them into a bottle with a pint of highly rectified spirits of wine, place them in a moderate heat, shaking the bottle often for several days, and there will then be obtained a strong yellow tincture, which must be strained off from the dregs through a coarse linen cloth; put back this tincture into the bottle, add three ounces of good seed-lac, powdered grossly, place the mixture again in a moderate heat and shake it till the seed-lac be dissolved. The lacquer is then strained and put into a well corked bottle.

The arnotto is encreased, in proportion, where it is desired to have the laquer warmer or redder than this composition; and diminished where it is wanted cooler, or nearer a true yellow.

This laquer, properly managed, is extremely good, and of moderate price; but the following which is cheaper, is not greatly inferior to it, and may be made where the Spanish-arnotto cannot be procured good.

Take one ounce of turmeric root, ground, and half a drachm of the best dragon's blood. Put them to a pint of spirits of wine, and proceed as above, and the varnish may be rendered of a redder or truer yellow cast by diminishing the proportion of dragon's blood.

Saffron is sometimes used to form the body of colour in this laquer, instead of the turmeric; it makes a warmer but more expensive yellow, and as turmeric has the advantage in forming a much stronger tinge in spirits of wine, it receives the preference.

Aloes and gamboge are also sometimes used in laquers for brass; aloes are not necessary where turmeric or saffron is used; and the gamboge, though a strong juice in water, affords but a weak tinge in spirits of wine.

520. *A laquer for tin, to imitate a yellow metal.* Take one ounce of turmeric root, of dragon's blood two drachms, and one pint of spirits of wine; add a sufficient quantity of seed-lac,

521. *A laquer for locks, &c.* Seed-lac varnish alone, or with a little dragon's blood: or a compound varnish of equal parts of seed lac and resin, with or without the dragon's blood.

522. *A gold-coloured laquer for gilding leather,* The *gilt leather* used for skreens, room-borders, &c. is leather covered with *silver* leaf, and laquered with the following composition:

Take four pounds and a half of fine white resin, of common resin the same quantity, of gum-sandarach two pounds and a half, and of aloes two pounds; bruise those which are in great pieces, mix them together, put them into an earthen pot, over a good charcoal fire, or any fire without flame. Melt all the ingredients, stirring them well with a spatula, that they may be thoroughly mixed, and prevented also from sticking to the bottom of the pot. When they are perfectly melted, and mixed, add gradually to them seven parts of linseed oil, and stir the whole with the spatula. Make the liquid boil, stirring it all the time to prevent the sediment, from sticking to the bottom of the vessel. When the varnish is boiled seven or eight hours, add gradually half an ounce of litharge, or half an ounce of red-lead, and when they are dissolved, pass the varnish through a linen cloth, or flannel bag.

The way of knowing when the varnish is sufficiently boiled, is by taking a little on some instrument, and if it draws out and is ropy, and sticks to the fingers, drying on them, it is prepared.

SECTION V.

OF GILDING.

523. *Gilding* is the application of gold to the surfaces of bodies; and is of two kinds, according to the method of applying the gold.

Wood, leather, paper, and soft substances, are gilt by fastening on leaves of gold by some cement. The gilding of wood, and similar substances, is of three kinds; *oil gilding*, *burnished-gilding*, and *japanners'-gilding*. Metals are gilt by a chemical application of the gold to the surface, and this is called *water-gilding*.

524. *Of gold leaf.* There are three kinds of gold leaf in use.

Pure gold-leaf, made by hammering gold between the leaves of a book made of skins, till it is sufficiently thin.

Pale gold-leaf, with a greenish colour, is made of gold alloyed with silver.

Dutch gold, (brought from Holland,) is copper-leaf coloured by the fumes of zinc.

It is cheaper than true leaf-gold, and useful where large quantities of gilding are wanted, which can be defended from the weather, and where great nicety is not required; but it changes colour when exposed to moisture; and, in all cases, its beauty is soon impaired, unless secured by varnish. Being only a cheap substitute for true gold-leaf, it may be useful where durability is not an object.

525. *The instruments necessary for gilding*, are the cushion, knife, tip, and fitch.

The *cushion*, for receiving the leaves of gold from the books, is made by covering a board of about eight inches square, with a double thickness of flannel, and over that a piece of buff leather, and fastening it tight round the edges.

The *knife* for cutting the leaves into the requisite sizes, is made like a pallet knife, with an edge not too sharp.

The *tip*, a tool made by fastening the long hairs of a squirrel's tail between two cards, is used for taking up the gold-leaf after it is cut, and laying it on the article to be gilded.

A *fitch pencil* is used for the same purpose as the last, in taking up very small bits of gold-leaf. A *ball of cotton* is used for pressing down the leaf, after it is laid on; a large *camel's hair brush* for dusting the work, and clearing away the superfluous gold.

526. *Oil gilding*. Prime your work first with boiled linseed-oil and white-lead; when dry, do it over with a thin coat of gold size, consisting of stone-ochre ground in fat-oil. When that is so dry as to feel clammy, it is fit for gilding. Spread your leaves of gold upon the cushion, cut them into slips of the proper width for covering your work, breathe upon your tip, as by moistening it thus, it will cause it to take up the leaves from the cushion. Apply them by the tip on the proper parts of your work, press them down by the ball of cotton. Repair, by putting small pieces of gold on any parts which you have omitted to cover. When your work is covered, let it dry, and then clear it off with the brush.

This sort of gilding, the easiest and least expensive, will stand the weather, and may at any time be cleaned with a little water.

527. *Burnished gilding* is the sort of gilding generally used for picture-frames, looking-glasses, &c.

The wood intended to be gilt in this manner, should first be sized, then done over with about eight coats of size and whiting, to cover it with a body of considerable thickness. Having laid a sufficient quantity of whiting upon the work, it must be cleaned off, freeing all the cavities, and hollows from the whiting that may have choaked them up, and by proper moulds and tools, restoring the sharpness of the mouldings.

It then receives a coat of size, made by boiling Armenian bole with parchment size. As this must not remain till it is quite dry, it is prudent not to lay on more at a time than can be gilt before it becomes too dry.

The work being thus prepared, place it a little declining from you, and with clean water and a hair pencil moisten a part of it, and then apply the gold by the tip to the moistened part. The gold will immediately adhere close to the work: proceed to wet the next part, and apply the gold as before, repeating this operation till the whole is completed; let not any drops of water come upon the gold already laid on, therefore no part should be missed in going over it at first, since it is not so easily mended as oil gilding.

The work being thus gilt, remains twenty-four hours; when the parts designed to be burnished are polished with a dog's tooth, or an agate burnisher, but the gilding must not be quite dry when it is burnished.

528. *Japanner's Gilding.* To gild japanned work, we draw with a hair pencil, in gold size, the intended ornaments, and afterwards apply gold-leaf or gold powder.

The gold size is prepared in the following manner: take of linseed oil, and of gum animi four ounces. Boil the oil in a proper vessel, add the gum animi gradually in powder, stirring each quantity about in the oil, till it be dissolved, then put in another, till the whole be mixed with the oil. Let the mixture continue to boil till it acquire a thicker consistence than tar; then strain the whole through a coarse cloth, and keep it for use; but when applied it must be mixed with vermillion and oil of turpentine.

Having laid on the gold size, and allowed it to dry, the gold-leaf is applied in the usual way, or if it is not wanted to shine so much, gold powder is applied, which is made by grinding gold leaf upon a stone with honey, and afterwards washing the honey away with water. If the gilding is varnished, Dutch gold may be used, instead of real gold powder, or aurum musivum may be used.

529. *To write on paper with letters of Gold.* Put gum arabic into writing ink, and write in the usual way. When the writing is dry, breathe on it; the warmth and moisture will soften the gum, and cause it to fasten on the gold leaf, which may be laid on in the usual way, and the superfluous part brushed off. Or instead of this use japanner's size.

530. *To lay gold upon white earthen-ware, or glass.* Draw your design upon the vessel to be gilt with japanner's gold size, moistening it if necessary with oil of turpentine. Set your work in a room free from dust, to dry, for an hour, then place it so near the fire that you could just bear the heat of it with your hand for a few seconds. Let it remain there till it feels clammy, then lay some gold-leaf on in the usual way. Then put the ware into an oven to be baked for about three hours.

Glasses, &c. are gilt by drawing the figures with shell gold mixed with gum arabic, and borax. Then apply sufficient heat to it, and lastly, burnish it.

531. *To gild on glass or porcelain, by burning-in.* Dissolve gold in aqua-regia, evaporate the acid by heat, and you will obtain a gold powder; or precipitate the gold from the solution by pieces of copper. Lay this gold on with a strong solution of borax and gum water, and it may be burned-in.

532. *To gild metals.* One method of applying gold upon metals is by first cleaning the metal to be gilt; gold-leaf is then laid on it. This rubbed with a polished blood stone, and a certain degree of heat, adheres perfectly well. In this manner silver-leaf is fixed and burnished upon brass, in the making of what is called *French plate*; and sometimes gold-leaf also is burnished upon copper and iron.

533. *Gilding by amalgamation* is by previously forming the gold into a paste, or amalgam, with mercury. But to obtain an amalgam of gold and

mercury, the gold is reduced into thin plates or grains, heated red-hot, and thrown into mercury previously heated, till it begins to smoke. Upon stirring the mercury with an iron rod, the gold totally disappears. The proportion of mercury to gold is generally as six or eight to one.

The method of gilding by amalgamation, is chiefly used for gilding copper, or an alloy of copper, with a small portion of zinc, which receives the amalgam more readily, and is preferable on account of its colour, resembling that of gold more than the colour of copper.

When the metal to be gilt is wrought or chased, it is previously covered with quicksilver before the amalgam is applied, that this may spread easier; but when the surface of the metal is plane, the amalgam may be applied to it directly.

The metal to be gilt is first rubbed with aqua-fortis, which cleans the surface from any rust or tarnish that might prevent the union of the metals. The amalgam is then spread equally over the surface by a brush, and the mercury is evaporated by heat sufficient for that purpose; if the heat be too great, part of the gold also may be expelled, and part of it will run together, and leave some of the surface of the metal bare. While the mercury is evaporating, the work is from time to time taken from the fire, and examined, that the amalgam may be spread more equally by means of a brush; and any defective parts again covered, and that the heat may not be too suddenly applied. When the mercury has evaporated, which is known by the surface becoming entirely of a dull colour, the metal then undergoes other operations, by which it receives the fine gold colour.

First, the gilded piece of metal is rubbed with a *scratch-brush* (a brush made of brass wire), till its surface is quite smooth; it is then covered with *gilding wax*, and again exposed to the fire till the wax be burnt off. This wax is composed of bees-wax, mixed with either red ochre, verdigris, copper scales, alum, vitriol, or borax; but the saline substances are sufficient without any wax.

The colour of the gilding is heightened by this operation.

The gilt surface is then covered with a saline composition of nitre, alum, or other vitriolic salt, ground together, and mixed into a paste with water and urine. The metal thus covered is exposed to a certain degree of heat, and then quenched in water. By this method its colour is further improved, and brought nearer to that of gold. This effect seems to be produced by the acid of nitre (which is disengaged by the sulphuric acid of the alum, during the exposure to heat) acting upon any particles of copper which may happen to lie upon the gilded surface.

Lastly, some artists think that they give an additional lustre to their gilt work, by dipping it in a liquor prepared by boiling some yellow materials, as sulphur, orpiment, or turmeric. The only advantage of this operation is, that part of the yellow matter remains in some of the hollows of the carved work, in which the gilding is apt to be more imperfect, and to which it gives a rich and solid appearance.

534. *Gilding iron or steel.* In gilding iron or steel by means of an amalgam, as the metal has no affinity for the mercury, an agent is employed to dispose the surface to receive the gilding. This agent is, a solution of mercury in nitrous acid (aqua fortis), or what workmen call quicksilver water, applied to the parts to be gilded; the acid, by a stronger affinity, seizes on a portion of the iron, and deposits in its place a thin coating of mercury, which will not refuse a union afterwards with the gold amalgam that may be applied; by this process, the nitrous acid injures the surface of the metal, and the union of the mercury being very slight, a bright and durable gilding cannot be obtained.

Another method. Apply a solution of *blue vitriol* with a camel's-hair pencil, to the parts of the steel to be gilt, and by a chemical action, similar to that we described as taking place when a solution of nitrate of mercury is employed, a thin coating of copper is precipitated on the metal. The copper has an affinity for mercury, and an union is thus effected between the amalgam and the iron or steel. But the surface is injured by the action of the acid employed, and still a heat sufficient to volatilize the mercury must be afterwards used.

535. *Gilding of iron by heat.* When the surface has been polished bright, it is heated till it become blue. Gold-leaf is then applied, and burnished down. It is then heated again, another layer of gold burnished on it, and in this manner three or four coats are given, according to the intended strength of the gilding. This though a more labori-

ous process than the two last, is not attended with so much risk.

536. *An improved process for gilding iron or steel.* This process, less known among artists than it deserves to be, cannot fail to be useful to those who gild iron or steel. The first part of the process consists in pouring over a solution of gold in nitro-muriatic acid (aqua-regia), about twice as much ether. This must be done with caution, and in a large vessel. These liquids are then shaken together, and as soon as the mixture is at rest, the ether will be seen separating itself from the nitro-muriatic acid, and floating on the surface. The nitro-muriatic acid becomes more transparent, and the ether darker than they were before; because the ether has taken the gold from the acid. The whole mixture is then poured into a glass funnel, with a small aperture which must not be opened till the fluids have separated themselves from each other. It is then opened, and the nitro-muriatic acid will run off, it having taken off the lowest place by its greater gravity; the aperture is then shut, and the funnel will be found to contain nothing but ether mixed with gold. This is preserved for use in bottles well closed.

In order to gild iron or steel, the metal is first well polished with emery, or the finest crocus martis or colcothar of vitriol, and common brandy. The auriferous ether is then applied with a small brush; the ether soon evaporates, and the gold remains on the surface of the metal. The metal may then be put into the fire, and afterwards polished. By means of this auriferous ether, figures of all kinds may be delineated on iron, by a pen or fine brush.

Instead of ether, the essential oils of turpentine or lavender may be used, which will also take gold from its solution.

537. *Cold gilding of silver.* Dissolve gold in nitro-muriatic acid, dip some linen rags in the solution, then burn them and preserve the ashes. Whatever is to be gilded must be previously well bur-

nished; a piece of cork is then dipped, first into a solution of salt and water, and afterwards into the black powder; and the piece, being rubbed with it, must be burnished. This powder is frequently used for gilding delicate articles of silver.

538. *Gilding of brass or copper.* That the surface of fine instruments of brass, may be kept longer clean, they may be gilded in the following manner.

Evaporate a saturated solution of gold to the consistence of oil, and suffer it to shoot into crystals, which must then be dissolved in pure water, and the articles to be gilded being immersed in it, are then washed in pure water, and afterwards burnished. This process must be repeated, till the articles have been well gilt. A solution of gold crystals is preferred to a mere solution of gold, because, in the latter, there is always a portion of free acid, which will, by exercising more or less action on the surface of the brass or copper, injure its polish.

539. *Grecian gilding.* Dissolve mercury in muriatic acid (spirits of salt), which will give a muriate of mercury. Equal parts of this and sal ammoniac are then mixed and dissolved in aqua fortis. Put some gold into this, and it will dissolve. This applied to silver, becomes black; but, by heating, it assumes the appearance of gilding.

540. *To make shell-gold.* Grind up in a mortar gold-leaf with honey, then wash away the honey with water, and mix the gold powder with gum water. This may be applied to any article with a camel's-hair pencil, in the same way as any other colour.

SECTION VI.

OF SILVERING.

Wood, paper, and other substances, are silvered in the manner in which gilding is performed, using silver-leaf instead of gold.

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541. *To silver copper or brass.* Cleanse the metal with aqua fortis, by washing it lightly, and then plunging it into water; or by scouring it with salt and tartar with a wire brush. Dissolve silver in aqua fortis, put copper into the solution; this will precipitate the silver in a state of a metallic powder. Take about twenty grains of this silver powder, and mix with it two drachms of tartar, the same quantity of common salt, and half a drachm of alum; rub the articles with this composition till they are perfectly white, then brush it off, and polish it with leather.

Another method. Precipitate silver from its solution in aqua fortis by copper, as before; to half an ounce of this silver, add common salt and sal ammoniac, of each two ounces, and one drachm of corrosive sublimate; rub them together, make them into a paste with water, and with this, copper utensils of every kind, that have been previously boiled with tartar and alum, are rubbed; after which they are made red hot and polished.

542. *To silver the dial-plates of clocks, &c.* Take half an ounce of silver leaf, add to it an ounce of double refined aqua fortis, put them into an earthen pot, place them over a gentle fire till the whole is dissolved; then take off the pot, and mix the solution in a pint of clear water; after which, pour it into another clean vessel, to free it from grit or sediment; add a spoonful of common salt, and the acid, which has now a green tinge, will immediately let go the silver particles, which form themselves into a white curd; pour off the acid, mix the curd with two ounces of salt of tartar, half an ounce of whiting, and a large spoonful of salt, and mix it well up together, when it will be ready for use.

Having cleared the brass from scratches, rub it over with a piece of old hat and rotten-stone, to clear it from all greasiness, and then rub it with salt and water with your hand, take a little of the composition just described on your finger, rub it over where the salt has touched, it will adhere to the brass, and completely silver it. Then wash it well with water, to take off what aqua fortis may remain in the composition when dry, rub it with clean rag, and give it one or two coats of varnish, prepared according to the directions already given.

This silvering, though not durable, may be improved by heating the article, and repeating the operation till the covering seems sufficiently thick.

543. *Silver plating.* The coat of silver applied to the surface of the copper by the means just mentioned, is thin, and not durable. A method more substantial is as follows: form small pieces of silver and copper, tie them together with wire, putting a little borax between, (the proportion of silver may be to that of the copper as 1 to 12). Subject them to a white heat, when the silver will be firmly fixed to the copper. The whole is now passed between rollers, till it be of the required thickness for manufacturing articles of use or ornament.

544. *To make French plate,* heat the copper articles intended to be plated, and burnish silver-leaf on it with a burnisher.

545. *To make shell silver.* Grind leaf silver with gum-water or honey; wash away the gum or honey, and the powder that remains is used with gum-water, or glaire of eggs laid on with a hair pencil.

546. *To silver looking glasses,* you must be prepared with the following articles.

First, a square marble slab, or smooth stone, well polished, and ground exceedingly true, the larger the better, with a frame round it, or a groove cut in its edges, to keep the superfluous mercury from running off. Secondly, lead weights covered with cloth, to keep them from scratching the glass, from one pound weight to twelve pounds each, according to the size of the glass which is laid down. Thirdly, rolls of tinfoil. Fourthly, mercury or quicksilver, with which you must be well provided; then proceed as follows.

The tinfoil is cut a little larger than the glass every way, and laid flat upon the stone, and with a straight piece of hard wood, about three inches long, stroked every way, that there be no creases or wrinkles in it, a little mercury is then dropped upon it, and with a piece of cotton, wool, or hare's foot, spread it all over the foil, so that every part may be touched with the mercury. Then keeping the marble slab nearly level with the horizon, pour the mercury all over the foil, cover it with a fine paper, and lay two weights near its lowest end, to keep the glass steady, while you draw the paper from between the silver foil and the glass, which must be laid upon the paper. As you draw the paper, you must take care that no air bubbles be left, for they will always appear if left in at the first; you must likewise be sure to make the glass as clean as possible on the side intended to be silvered, and have the paper also quite clean, otherwise, when you have drawn the paper from under it, dull white streaks will appear, which are very disagreeable.

After the paper is drawn out, place weights upon the glass to press out the superfluous mercury, and make the foil adhere. When it has lain about seven hours in this situation, raise the stone about two or three inches at its highest end, that as much of the mercury may run off as possible; let it remain two days before you venture to take it up; but before you take the weights off, brush the edges of the glass gently, that no mercury may adhere to them; then take it up, and turn it directly over, with its face side downward, but raise it by degrees, that the mercury may not drip off too suddenly; for if, when taken up, it is immediately set perpendicular, air will get in between the foil and the glass at the top, as the mercury descends to the bottom; and your labour will be lost.

Another method is to slide the glass over the foil, without the assistance of paper.

547. *To silver glass globes.* Take half an ounce of clean lead, melt it with an equal weight of pure tin; add immediately half an ounce of bismuth, skim off the dross; remove the mixture from the fire, and before it grows cold, add five ounces of mercury, stirring the whole well together; then put the fluid amalgam fit for use into a clean glass.

When this amalgam is used for silvering, strain it through a linen rag; then gently pour some ounces of the liquid into the globe intended to be foiled; by means of a glass or paper funnel, reaching almost to the bottom of the globe, to prevent its splashing to the sides; the globe must then be dexterously inclined every way, though very slowly, to fasten the silvering; this done, let the globe rest some hours; repeat the operation till the fluid mass be spread even, and fixed over the whole internal surface; the superfluous amalgam is then poured out, and the outside of the globe cleaned.

548. *To silver the convex side of meniscus glasses for mirrors.* Take an earthen plate, on which pour plaster of Paris, mixed with water, of a proper consistence; then, before it grows stiff, lay the meniscus in the middle of the plate with its convex surface downwards, and press it until it lies close to the plaster; let it remain in this situation until the plaster becomes quite dry; after which, work a groove with your finger, round the outside of the meniscus, to let the superfluous mercury rest upon it; cut the tin foil to its proper size, press it with the meniscus into the plaster mould, to make it lie close; then cover it with the mercury, and slide it over the silvered foil; place now a weight upon it, and let it stand three days, raising it by degrees, that the mercury may drop off gradually. And after this method common window glass, &c. may be silvered.

549. *To lay paper prints on the inside of glass globes.* Cut off all the white part of your impression, so that nothing appear but the print; prepare strong gum arabic water, or size, with which brush over the face side of the print, then put it into the globe, and with a camel's-hair pencil, stick it evenly on, by this method you may put all the prints into the globe; let them dry twelve hours, then pour some prepared plaster of Paris, either white, or tinged, whatsoever colour you please, and turn the globe easily about, so that every part be covered; pour out the superfluous plaster, and the operation is finished.

SECTION VII.

OF TINNING.

550. Tinning is the art of covering any metal with a thin coating of tin. Copper and iron are the metals usually tinned, to prevent them from being corroded by rust, as tin is not so easily acted upon by the hair or moisture as are iron and copper.

What is commonly called tin-plates, or sheets, so much used for utensils of various kinds, are in fact iron plates coated with tin.

The principal circumstance in the art of tinning, is to have the surfaces of the metal to be tinned perfectly clean and free from rust, and also that the melted tin be perfectly metallic, and not covered with any ashes or calx of tin.

551. *The tinning of iron.* When iron plates are tinned, they are first scoured, then put into a pickle (oil of vitriol diluted with water), which dissolving the rust or oxyde that was left after scouring, renders the surface perfectly clean. They are then again washed and scoured. They are now dipped into melted tin, whose surface is covered with oil, to defend it from the air. By this means, the iron coming into contact with the melted tin, in a perfectly metallic state, it comes out completely coated.

When only a small quantity of iron is to be tinned, it is heated, and the tin is rubbed on with a piece of cloth, or some tow, the iron is first sprinkled with some powdered resin, to reduce the tin that may be oxydated. Any inflammable substance, as oil for instance, will have the same effect, owing to its attraction for oxygen.

552. *The tinning of copper.* Sheets of copper are tinned as iron. Copper boilers, saucepans, and other kitchen utensils, are tinned after they are made; by being first scoured, then made hot, and the tin rubbed on with resin. Nothing ought to be used for this purpose but pure grain tin; but lead

mixed with tin, adulterates its quality, though it makes it lie on more easily. This is a very pernicious practice, which ought to be reprobated.

553. *To whiten brass or copper by boiling.* The brass or copper is put into a pipkin with some white tartar, alum, and grain tin, and the whole boiled together. The articles soon become covered with a coating of tin, which, when polished, will look like silver. It is in this manner that pins, and many sorts of buttons, are whitened.

554. *Metallic watering.* A new art has been lately discovered, by accident, in France, by M. Baget, called metallic watering (*moiré metallique.*) It depends upon the action of acids, either pure or mixed together, and in different degrees of dilution, on alloys of tin. The variety of designs resemble mother-of-pearl, and reflect the light in the form of clouds.

The process is this:—first dissolve four ounces of muriate of soda in eight ounces of water, and add two ounces of nitric acid:—second mixture—eight ounces of water, two ounces of nitric acid, and three ounces of muriatic acid:—third mixture,—eight ounces of water, two ounces of muriatic acid, and one ounce of sulphuric acid. One of these mixtures is to be poured warm upon a sheet of tinned iron, placed upon a vessel of stone ware; it is to be poured on in separate portions, until the sheet is completely watered; it is then to be plunged into water, slightly acidulated, and washed. The watering, obtained by the action of these different mixtures upon tinned iron, imitates, very closely, mother-of-pearl and its reflections; but the designs, although varied, are quite accidental.

By heating the tinned iron to different degrees of heat, stars, fern-leaves, and other figures, are produced; and, by pouring one of the above mixtures, cold, upon a plate of tinned iron, at a red heat, a beautiful granular appearance is obtained. These metallic waterings will bear the blow of a mallet, but not of a hammer; hence, the invention may be used for embossed patterns, but not for those which are punched. Different colours and shades may be given by varnishes, which, when properly polished, will set off the beauty of the watering.

SECTION VIII.

OF BRONZING.

555. Bronzing is colouring of plaster figures, &c. with metallic powders, in order to make them appear as if made of copper or other metals.

The powders used for this purpose are fine copper filings, aurum musivum, or copper precipitated from its solution in aqua fortis by iron. Having done over the substance to be bronzed with isinglass size, japanner's gold size, or, with drying oil, or oil-paint, the powders are rubbed on, the projecting parts receiving more of the powder than the cavities, to imitate on those parts which are liable to be rubbed the brightness of bronze.

SECTION IX.

OF SOLDERING.

556. Soldering is the art of joining two pieces of metal together by a thin piece of metal interposed between them. Thus tin is a solder for lead; brass, gold, or silver, are solders for iron, &c.

557. *To make silver solder.* Melt two parts of fine silver, one part of brass; but do not keep them long in fusion, lest the brass fly off in fumes; and your solder is made.

558. *Another for coarser silver.* Melt four parts of fine silver, and three of brass; throw in a little borax, and pour it out as soon as it is melted, and the solder is prepared.

559. *A solder for gold.* Melt one part of copper, one part of fine silver, and two parts of gold; add a

little borax when it is just melted, then pour it out immediately, and it is fit for use.

560. *The method of soldering gold or silver.* After the solder is cast in an ingot, it would be more ready for use, were you to draw it into small wire, or flatten it between two rollers. Then cut it into little bits, join your work together with fine soft iron wire, with a camel's-hair pencil dipt in borax finely powdered, and well moistened with water, touch the joint intended to be soldered; place a little solder upon the joint, apply it upon a large piece of charcoal, and, with a blow-pipe and lamp, blow upon it through the flame until the solder melts, and it is done.

561. *To cleanse silver or gold, after it is soldered.* Melt it red hot, let it cool, then boil it in alum water, in an earthen vessel, and it will be as clean as when new. If it be gold you are to clean, boil it in urine and sal ammoniac.

562. *A solder for lead* is composed of two parts lead and one part tin: its goodness is tried by pouring the bigness of a crown piece upon the table; if it be good, there will arise little bright stars in it: when you use this solder apply resin.

563. *A solder for tin.* This composition consists of four parts of pewter, one of tin, and one of bismuth; melted together, and run into narrow thin lengths.

564. *A solder for iron.* Nothing here is necessary, but good brass, with borax applied, mixed with water to the consistence of paste.

CHAPTER IX.

MANUFACTURES.

SECTION I.

THE MANUFACTURE OF PAPER AND PARCHMENT.

565. PAPER is manufactured chiefly of linen rags in Europe. These rags, after being sorted into different classes, according to their respective qualities, are put into a machine called the *cutting-table*, where they are divided into minute pieces. They are then placed in another engine, called a *duster*; which is covered with a wire-net, and put in motion by machinery; it separates the shreds from the dust, which forces it through the wire. The rags are reduced to a pulp in mills, by cylinders, with iron blades; after which the stuff is conveyed to a repository, that supplies the vat, from which the pulp is drawn.

In order to cast this pulp into paper, the workman immerses in the vat a mould composed of wire-cloth, and furnished with a frame to retain the stuff: he draws out as much of the pulp as is necessary for one sheet, on which he lays a felt, for the purpose of absorbing the moisture; and thus places alternately a sheet and a felt, till he has formed six quires of paper. When the last sheet is covered with felt, the whole is pressed, the sheets are then suspended on cords to dry. The next operation is *sizing*. This is performed by plunging a few sheets together, in a vessel full of size, into which a small portion of alum is thrown. The paper is now carried to the drying-room, and after being gradually dried, to the finishing-room, where it is pressed, selected, examined, folded, formed into quires of 24 sheets, and finally into reams, consisting of 20 quires each. This is termed writing-paper; as it is adapted for this purpose by the process of sizing.

The various kinds of papers are blotting, brown, and coarse paper, which will not bear ink, drawing, engraving, or printing paper. These, though prepared in the usual way, are nevertheless not sized so highly as those papers which are intended for the pen. Among the various vegetable substances employed as a substitute for linen rags in the manufacture of paper, barley-straw is the most profitable, as it is the most abundant, but it will only serve for common purposes; as it communicates an unpleasant tinge.

566. To make *stained paper*. This is done by applying, by soft brushes, any of the colours used for tinging other substances, after tempering them properly with size or gum-water. If the paper is to be of a uniform colour, it must be fixed by several thin coatings, each being suffered to dry before another is applied; otherwise the shade will appear clouded.

567. To make *marbled paper*. Dissolve gum in a trough, into which plunge each sheet of paper. This done, range the colours on the table, on which the trough is placed, and the workmen dip a brush of hog's hair into any colour, which they sprinkle on the surface of the liquor. When the colours are floating on the liquor, they draw a pointed stick from one end of the trough to the other, to agitate the liquors and colours, and give those beautiful shades you behold in marbled paper.

568. *Papier mache* is made of cuttings of white or brown paper, boiled in water, and beaten in a mortar till they are reduced to a paste, then the mass is boiled with a solution of gum arabic, or of size, to give tenacity to the paste, which is afterwards formed into toys, snuff boxes, &c. by pressing it into oiled moulds. When dry, it is covered with a mixture of size and lamp-black, and afterwards varnished.

569. *Rice paper* is a curious sort of paper, made by the Chinese; it is semi-transparent, of a firm texture, and feels somewhat like the article manufactured from the *papyrus*.

But the Chinese make paper from the rind or bark of mulberry tree, the elm, the bamboo, and cotton tree. In fact, every different province has its own provincial paper. The second skin of the bamboo bark is peculiarly soft and white. This they beat in fair water into a pulp, which they take up in large moulds, so that some sheets are above twelve feet in length. They are completed by dipping them in alum-water, which serves in place of our size. Some, ignorant of the facts we have disclosed regarding the manufacture of the Chinese paper have gaped with astonishment at the variegated colours of the Chinese *rice-paper*, as it is called. But the fact is this. Each province not only manufactures a paper peculiar to itself, but stains it pink, green, or straw colour, as their fathers from time immemorial have done.

570. *Parchment* is the skin of sheep or goats, prepared for writing and covering books. The skin is stripped of its wool, passed through the lime-pit. The skinner then stretches it on a frame, perforated longitudinally with holes furnished with wooden pins that may be turned at pleasure, like those of a violin, to stretch the skin like a drum head. The skin being thus sufficiently stretched on the frame, the flesh is pared off with a sharp instrument, it is then moistened with a rag, and white chalk reduced to a fine dust, strewed over it: then with a large pumice-stone, the workman rubs over the skin, and thus scours off the remains of the flesh. They then go over it again with an iron instrument; moisten it as before, and rub underneath with the pumice-stone without any chalk; this smooths and softens the flesh-side very considerably. They drain it again, by passing over it the iron instrument as before.

The flesh-side thus drained, they pass the iron on the hair-side; then stretch it tight on the frame by means of the pins, and go over the flesh-side again with the iron; this finishes its draining; the more the skin is drained, it becomes the whiter. They now throw on more chalk, sweeping it over with a piece of lamb-skin that has the wool on; this smooths it further, and gives it a white knap. When dried, it is taken off the frame, by cutting all round. The skin, thus far prepared by the skinner, is taken by the parchment-maker; who first scrapes or pares it dry on the summer*, with an iron instrument like that above named, only finer and sharper; with this, worked with the arm from the top to the bottom of the skin, he takes away one half of its thickness, and the skin thus equally pared on both sides, is rubbed with the pumice-stone, to smooth it. This last preparation is performed on a bench covered with a sack stuffed with flocks,

* A *summer* is a calf-skin, stretched in a frame.

and it leaves the parchment fit for writing upon. The parings thus taken off the leather, are used in making glue, size, &c.

571. *Vellum* is nothing but parchment made of the skins of sucking calves. This has a much finer grain, it is whiter and smoother than parchment; but is prepared in the same manner, except that vellum is not like parchment, passed through the lime-pit.

572. *State of the papyrus manuscripts found at Herculaneum.* Sir Humphrey Davy says, that the nature of these manuscripts had been generally misunderstood; that they had not, as is usually supposed, been carbonized by the operation of fire, and that they were in a state analogous to peat, or Bovey coal, the leaves being generally cemented into one mass by a peculiar substance, which had formed during the fermentation and chemical change of the vegetable matter composing them, in a long course of ages.

An examination of the excavations that still remain open at Herculaneum confirm the opinion that the manuscripts had not been acted on by fire. He found a small fragment of the ceiling of one of the rooms, containing lines of gold leaf and vermillion in an unaltered state; which could not have happened if they had been acted upon by any temperature sufficient to convert vegetable matter into charcoal. Moisture, by its action upon vegetable matter, produces decomposition, which may be seen in peat bogs in all its different stages; when air and water act conjointly on leaves or small vegetable fibres, they soon become brown, then black; and, by long continued operation of air, even at common temperatures, the charcoal itself is destroyed, and nothing remains but the earths which entered into the constitution of the vegetable substance. The number of manuscripts and of fragments originally brought to the museum at Portici amounted to 1,696; of these 88 have been unrolled, and found in a legible state; 319 more have been operated upon, and, more or less, unrolled, and found not to be legible; while 24 have been presented to foreign potentates. Amongst the 1,265 that remain, and which Sir Humphrey examinedwith attention, by far the greatest number consist of small fragments, or of mutilated or crushed manuscripts, in which the folds are so irregular, as to offer little hopes of separating them so as to form connected leaves; from 80 to 120 are in a state which present a great probability of success, and of these the greater number are of the kind in which some volatile vegetable matter remains, and to which a chemical process may be applied with the greatest hopes of useful results. Of the 88 manuscripts containing characters, with the exception of a few fragments, in which some lines of Latin poetry have been found, the great body consists of works of Greek philosophers or sophists; nine are of Epicurus, thirty-two bear the name of Philodemus, three of Demetrius, and one of each of these authors, Colotes, Polystratus, Carneades, and Chrysippus; and the subjects of these works, and the works of which the names of the authors are unknown, are either natural or moral philosophy, medicine, criticism, and general observations on the arts and manners of life.

SECTION II.

THE MANUFACTURE OF PINS AND NEEDLES.

573. Pins are made of brass wire. When the wire is received at the manufactory, it is wound off from one wheel to another, and passed through a circle of a smaller diameter in a piece of iron. When reduced to its proper size, it is straightened by drawing it between iron pins, fixed in a board in a zigzag manner. It is afterwards cut into lengths of about four yards, and then into smaller pieces, every length being sufficient for six pins. Each end of these is ground to a point.

This operation is performed by boys, who each sit with two small grindstones before him turned by a wheel. Taking up a handful, he applies the wires to the coarsest of the two stones, moving them round that the points may not become flat. He then gives them a smoother and sharper point on the other stone: a lad of twelve years of age, can point 16,000 in an hour. When the wire is pointed, a pin is taken off from each end, till it is cut into six pieces.

The next operation is to form the heads, or *head-spinning*, as it is termed. This is done by a spinning wheel, one piece of wire is with rapidity wound round another, and the interior one being drawn out, leaves a hollow tube between the circumvolutions. It is then cut into shears every two turns of the wire, forming one head. These are softened by throwing them into iron pans, and placing them in a furnace till they are red hot. As soon as they are cold, they are distributed to children, who sit with anvils and hammers before them. These they work with their feet by means of a lathe. They take up one of the lengths, and thrust the blunt end into a quantity of the heads which lie before them, catching one at the extremity, they apply it immediately to the anvil and hammer, and by a motion or two of the foot, the point and the head is fixed together in much less time than can be described, and with a dexterity that can only be acquired by practice. The pins are thrown into a copper, containing a solution of tin and wine lees. Here they remain for some time, and when taken out assume a dull white appearance, in order to give them a polish, they are put into a tub containing a quantity of bran, which is set in motion by turning a shaft that runs through its centre, and thus, by means of friction, the pins become entirely bright. They are now separated from the bran, which is performed by a mode exactly similar to the winnowing of corn; the bran flying off, and leaving the pin behind fit for sale.

574. NEEDLES are made of steel. The first thing in the manufacture of needles, is to pass the steel through a coal fire, and under a hammer to bring it to a round form, then it is drawn through a large hole of a wire-drawing iron, and returned into the fire, and again drawn through a second hole smaller than the first, and thus successively, till it has acquired a degree of fineness requisite; observing every time it is drawn to rub it with lard to render it more manageable.

The steel thus reduced, is cut to the proper length of the needles: these pieces are flatted at one end, to form the eye; they are then put into the fire to soften; then taken out, and the head pierced by a puncheon of well tempered steel, and laid on a leaden block, to bring out, with another puncheon, the little piece of steel remaining in the eye. The corners of the heads are then filed off, and a little cavity filed on each side of the flat of the head, the point is then formed with a file, and the whole is filed over. They are then laid on a long narrow iron, crooked on one end to heat red-hot, with charcoal fire, when taken out, are thrown into a bason of cold water to harden. On this operation much depends; too much heat burns them, too little leaves them soft: experience teaches the medium. When thus hardened, they are laid in a shovel on a fire, more or less brisk. This tempers them, and takes off their brittleness. They are then straightened one after another with a hammer.

The next process is the *polishing*. The people take 12 or 15,000 needles, and range them in little heaps on a piece of new buckram sprinkled with emery dust; they are then sprinkled with oil of olives. The whole is then made up in a roll and laid on a polishing table; a thick plank is now passed over the whole and the needles within become polished. They are then washed in hot water with soap and wiped in bran. The good are taken from the bad; the points are tipped with an emery stone turned by a wheel, and then packed up in parcels of 250 each for sale.

SECTION III.

THE MANUFACTURE OF LEATHER.

575. The leather tanned in England consists chiefly of *butts* or *backs, hides,* and *skins.*

Butts are made from the stoutest and heaviest ox hides, in the following manner: after the horns have been taken off, the hides are laid smooth in heaps for a couple of days in the summer, and about six in the winter; they are then hung on poles, in a close room or *smoke-house*, in which is kept a smouldering fire of wet tan. This occasions a small degree of putrefaction, the hair by this means is easily got off, by spreading the hide on a wooden horse, and scraping it well with a crooked knife. When the hair has been taken off, the hide is thrown into a pool of water, to cleanse it from the dirt, &c.; it again is spread on the wooden beam, and the grease, loose flesh, extraneous filth, &c. are carefully scrubbed out; the hides are then put into a pit of strong liquor, called *ooze*, an infusion of ground bark in water; this is termed *colouring ;* after this they are removed into another pit called a *scowering*, or water strongly impregnated with vitriolic acid, or with a vegetable acid prepared from rye or barley. This operation (which is called *raising*,) by distending the pores of the hides, occasions them more readily to imbibe the ooze, the effect of this is to combine with the gelatinous part of the skin, and form with it leather. The hides are then taken out of the scowering, and spread smooth in a pit called a *binder*, with a quantity of ground bark strewed between each. After laying a month or six weeks they are taken up; and the decayed bark and liquor being drawn out of the pit, it is filled again with strong ooze, when they are put in as before, with bark between each hide. They now lie two or three months, when the same operation is repeated; they then remain four or five months, when they again undergo the same process; and after being three months in the last pit, are completely tanned. The whole process requires from eleven to eighteen months, and sometimes two years, according to the substance of the hide, and discretion of the tanner. When taken out of the pit to be dried, they are hung on poles, and after being compressed by a steel pin, and beat out smooth by wooden hammers, called *battes*, the operation is complete; when thoroughly dry, they are fit for sale. Butts are chiefly used for the soles of stout shoes.

576. The leather which goes by the name of *hides*, is generally made of cow hides, or the lighter ox hides, manufactured in the following manner:

After the horns are taken off, the hides are washed, and put into a pit of water, saturated with lime; here they remain a few days, they are then taken out, and the hair scraped off on a wooden beam, as before described; they are then washed, and the loose flesh, &c. being taken off, they are removed into a pit of weak ooze, when they are taken up, and put down (which is technically termed *handling*) two or three times a day, for the first week; every second or third day they are shifted into a pit of fresh ooze, somewhat stronger than the former. In about six weeks they are put into a strong ooze, in which they are handled once or twice a week with fresh bark for two or three months. They are then removed into another pit, called a *layer*, in which they are laid smooth, with bark ground very fine, strewed between each side. After remaining here two or three months, they are taken up, when the ooze is drawn out, and the hides put in again with fresh ooze and fresh bark, where, after lying two or three months more, they are completely tanned; except a few very stout hides, which may require an extra layer: they are then taken out and hung on poles, and being hammered and smoothed with a steel pin, they are fit for sale when dry. These hides are called *crop hides*; and take from ten to eighteen months in tanning. They are used for the soles of shoes.

577. *Skins* are the general term for the skins of calves, seals, hogs, dogs, &c.

These, after being washed in water, are put into lime pits, where they are taken up and put down every third or fourth day, for about three weeks, to destroy the epidermis of the skin. The hair and excrescences are then scraped off, and they are put into a pit of water, called a *grainer* impregnated with *pigeon dung*, forming an alkaline ley, which in about ten days soaks out the lime, grease, and saponaceous matter. During this period, they are several times scraped over with a crooked knife, to work out the dirt and filth. The alkaline ley softens the skins, and prepares them for the reception of the ooze. They are then put into a pit of weak ooze, in the same manner as the hides, and being frequently handled, are by degrees removed into a stronger, and still stronger liquor, for a month or six weeks, when they are put into a strong ooze, with fresh bark ground very fine, and at the end of two or three months, according to their substances, are sufficiently tanned: when they are taken out, hung on poles, dried, and are fit for sale. These skins are afterwards dressed and blacked by the curriers, and are used for the upper leathers of shoes, boots, &c.

578. The lighter sort of hides, called *dressing hides*, as well as horse hides, are managed nearly in the same manner as skins; and are used for coach work, harness, &c. &c.

As the method of tanning above described, and all others in general use, are extremely tedious and expensive in their operation, various schemes have at different times been suggested to shorten the process and lessen the expence.

579. We may obtain the tanning principle, by digesting oak bark, or other proper material in cold water, in an apparatus nearly similar to that used in the saltpetre works. The water which has remained upon the powdered bark for a certain time, in one vessel, is drawn off by a cock, and poured upon fresh tan. This is again to be drawn off, and poured upon other fresh tan; and in this way the process should be continued to the fifth vessel. The liquor is then highly coloured, and marks from six to eight degrees upon the hydrometer for salts. This is called the tanning *lixivium*.

Test. The criterion for ascertaining its strength is the quantity of the solution of gelatine which a given quantity of it will precipitate. Isinglass is used for this purpose, being entirely composed of gelatine. And here it may be observed, that this is the mode of ascertaining the quantity of tanning principle in any vegetable substance, and consequently how far they may be used as a substance for hard oak.

The hides, being prepared in the usual way, are immersed for some hours in a weak tanning lixivium of two degrees strength. To obtain this, the latter portions of the infusions are set apart, or else some of that which has been partly exhausted by use in tanning. The hides are then to be put into a stronger lixivium, where, in a few days they will be brought to the same degree of saturation with the liquor in which they are immersed. The strength of the liquor will thus be considerably diminished, and must therefore be renewed. When the hides are by this means perfectly tanned, they are to be removed and slowly dried in the shade.

Obs. The length of time necessary to tan leather completely, according to the old process, is a great inconvenience; and there is no doubt that it may be much shortened by following the new method; but the leather so tanned has not been so durable as that which has been formed by the slower process.

580. Sir H. Davy in treating "on the Constituent Parts of Astringent Vegetables," thus speaks of tanning.

In considering the relation of the different facts that have been detailed, to the processes of tanning and of leather-making, it will appear sufficiently evident, that when skin is tanned in astringent infusions that contain, as well as tanning, extractive matters, portions of these matters enter with the tanning, into chemical combination with the skin. In no case is there any reason to believe that gallic acid is absorbed in this process; and M. Seguin's ingenious theory, of the agency of this substance, in producing the de-oxygenation of skin, seems supported by no proofs. Even in the formation of glue from skin, there is no evidence which ought to induce us to suppose that it loses a portion of oxygen; and the effect appears to be owing merely to the separation of the gelatine, from the small quantity of albumen with which it was combined in the organized form, by the solvent powers of water.

The different qualities of leather made with the same kind of skin, seem to depend very much upon the different quantities of extractive matter it contains. The leather obtained by means of infusion of galls, is generally found harder, and more liable to crack, than the leather obtained from the infusion of barks; and in all cases it contains a much larger proportion of tannin, and a smaller proportion of extractive matter.

When skin is very slowly tanned in weak solutions of the barks, or caoutchouc, it combines with a considerable proportion of extractive matter; and in these cases, though the increase of weight of the skin is comparatively small, yet it is rendered perfectly insoluble in water, and is found soft, and at the same time strong. The saturated astringent infusions of barks contain much less extractive matter, in proportion to their tannin, than the weak infusions; and when skin is quickly tanned in them, common experience shews that it produces leather less durable than the leather slowly formed.

Besides, in the case of quick tanning by means of infusions of barks, a quantity of vegetable extractive matter is lost to the manufacturer, which might have been made to enter into the composition of his leather. These observations shew, that there is some foundation for the vulgar opinion of workmen, concerning what is technically called the *feeding* of leather in the slow method of tanning; and though the processes of the art may in some cases be protracted for an unnecessary length of time, yet, in general, they appear to have arrived, in consequence of repeated practical experiments, at a degree of perfection which cannot be very far extended by means of any elucidations of theory that have as yet been known.

581. *Currying.* **The art of currying consists in rendering tanned skins supple, of uniform density, and impregnating them with oil, so as to render them in a great degree impervious to water.**

The strong and thick hides are employed for making the soles of boots and shoes, and these are rendered fit for their several purposes by the shoemakers after they are tanned; but such skins as are intended for the upper leathers and quarters of shoes, for the legs of boots, for coach and harness leather, saddles, and other things, must be subject to the process of currying.

These skins, after coming from the tanners, have fleshy fibres on them. They are well soaked in common water, then taken out and stretched upon a very even wooden horse; where with a paring knife all the superfluous flesh is scraped off, and they are again put into a pit or vessel to soak. After the *soaking* is completed, the currier takes them again out of the water, and having stretched them out, presses them with his feet, or a flat stone fixed in a handle, to make them more supple, and to press out all the filth that the leather may have acquired in tanning, and also the water it has absorbed in soaking.

The skins are next to be *oiled*, to render them pliant and impervious to wet. After they are half dried, they are laid upon tables, and first the grain side of the leather is rubbed over with a mixture of fish-oil and tallow; then the flesh side is impregnated with a large proportion of oil. After having been hung up a sufficient time to dry, they are taken down and rubbed, pressed, and folded, and then spread out, when they are rolled with considerable pressure upon both sides with a fluted board fastened to the operator's hand by a strap; by this means, and by repeating the rolling, a grain is given to the leather.

After the skins are curried, it may be required to colour them. The colours usually given to them are black, white, red, green, yellow, &c.

If the skins are to be blacked, the process varies according to the side of the skin to be coloured. Leather that is to be blacked on the flesh side, which is the case with most of the finer leather intended for shoes and boots, is coloured with a mixture of lamp black, oil, and tallow rubbed into the leather. And what is to be coloured on the grain side is done over with chamber-lye, and then with a solution of sulphate of iron, which turns it black.

582. *Water-proof leather.* To render leather water-proof, the following method is adopted.

Take a small pipkin or earthen vessel, and put in it three ounces of *spermaceti*, to be melted over a slow fire; then take three quarters of an ounce of *caoutchouc*, or Indian rubber, cut into thin slices; and the spermaceti will completely dissolve this substance. Add eight ounces of tallow, two ounces of hog's lard, and four ounces of amber varnish. The boots or shoes must be rendered dry and warm, and this cement well rubbed in, three or four times, with a brush.

583. *Morocco leather* is made of the skins of goats, tanned and dyed in a peculiar manner by the Turks. This process, originally invented in the

kingdom of Morocco, has given rise to the name of Morocco leather. *English* Morocco leather, used so largely for coach-linings, pocket-books, and the best kind of book-binding, is prepared from sheep-skins.

584. *Shagreen* is a sort of rough leather, prepared from the skin of the spotted shark. The skin of the fish is first stripped, then extended on a table, and covered with bruised mustard-seed: it is thus exposed to the weather for several days, and afterwards tanned.

The best shagreen imported from Constantinople, is of a brownish cast, and very hard; but, when immersed in water, it becomes soft and pliable; and may be dyed to any colour. It is often counterfeited, by preparing Morocco leather in the same manner as the skin of the fish. This fraud may be detected by the surface of the spurious manufacture peeling or scaling off, while that of the genuine article remains perfectly sound. Shagreen is employed principally in the manufacture of cases for mathematical instruments.

585. *Chamois,* is a kind of leather, either dressed in oil, or tanned, and much esteemed for its softness and pliancy.

It is prepared from the skin of the *chamois*, a wild goat, on the mountains of Dauphine, Savoy, Piedmont, and the Pyrenees. Besides the softness and warmth of the leather, it has the faculty of bearing soap without hurt. The true chamois leather is counterfeited with common goat, kid, and even sheep-skin.

586. *The working of tapestry.* This term is appropriated to hangings of wool and silk, frequently raised and enriched with gold and silver, representing figures of men, of animals, landscapes, &c. to ornament the walls of large rooms.

It is supposed that the English and Flemish, who were the first that excelled in tapestry, brought the art from some of the crusades against the Saracens. The English were the first who established the manufacture of tapestry in Europe. But the French certainly excell us in this. *The Gobelins* is a celebrated manufactory, established at Paris, for making tapestry, and other furniture. The house where this manufacture was carried on, by two brothers, Giles and John Gobelins, both excellent dyers, and the first who brought to Paris the secret of dyeing that beautiful scarlet colour, is still known by their name; though now called *Hôtel Royal de Gobelins*.

SECTION IV.

THE MAKING OF HATS.

587. Hats are generally made of wool, but feathers also have lately been employed in the manufacture of this article. Spanish wool, and that of hares, kids, rabbits, and beavers are employed in the manufacture of hats. The degree of fineness in hats depends on the quantity of hares' wool and beaver employed in their texture. The former is mixed with equal portions of the finest sheep or lambs' wool. The beaver is generally confined to the superficial facing of finer hats. The different processes are bowing, hardening, working, shaping, dyeing, stiffening, steaming, and ironing.

1. *Bowing*. The raw materials are laid upon a hurdle, about four feet square, fixed against the wall. The workman is provided with a deal bow, about eight feet long, with two bridges, over which is stretched a catgut. The materials being shovelled towards the right-hand end of the hurdle, the workman holding the bow horizontally in his left hand, lightly holds the bow-string, and pulls it with a knobbed stick, called the bow-pin. The string strikes part of the fur, and causes it to fly partly across the hurdle in a light open form. The quantity bowed at once is about half that required to make one hat. It is called a *batt*.

2. *Hardening*. The wool being evenly disposed on the hurdle, is covered with a cloth, and pressed gently by the hands of the workman. In a short time the stuff acquires sufficient firmness to bear handling. The cloth is then taken off, and a sheet of paper, with its corners doubled in, is laid upon the batt, which is folded over the paper as it lies, and its edges meeting one over the other, form a conical cap. The joining is easily made good by pressure with the hands on the cloth.

3. *Working* is effected by an apparatus called a battery,

consisting of a kettle of water (acidulated with sulphuric acid) and eight planks of wood joined together, and meeting in the kettle at the middle. The liquor being heated, the article is dipped from time to time, and worked on the planks with a roller, and by folding or rolling it up, and opening it again.

4. *Shape* is given by laying the conical cap on a block, of the intended size of the crown of the hat, and thus tying it round with a packthread, called a commander, and afterwards with a piece of iron, or copper bent for the purpose, the workman gradually drives down the commander all around, till he has reached the bottom of the block, and the crown is formed; what remains below the string, being the brim.

5. *Dyeing*. The nap of the hat being raised with a wire brush, it is dyed in a liquid prepared of logwood, and a mixture of green copperas and blue vitriol, the sulphates of iron and copper. The copper holds ten or twelve dozen hats which are kept boiling for about three quarters of an hour, then taken out and set to cool, and returned to the dye; and this ten or twelve times successively.

6. *Stiffening* is effected with beer grounds and glue. The workman has two boilers, one containing the grounds of strong beer, which are applied to the inside of the crown to prevent the glue from oozing through; another containing the glue stiffening, which is applied after the beer-grounds are dried, and then only upon the lower face of the flap, and the inside of the crown.

7. *Steaming*. The hat is now placed on the steaming-bason, which is a small hearth, or fire-place, raised three feet high, with an iron plate laid over it, exactly covering the hearth. On this plate the workman first spreads cloths, which being sprinkled over with water to secure the hat from burning, it is placed on them with the brim downwards. When moderately hot, the workman strikes gently on the brim with the flat of his hand, to make the jointings incorporate, so as not to appear.

8. *Ironing*. The hat is put again on the block, and brushed and ironed on a bench, called the stall-board. This is performed with an iron like that used in ironing linen; which being rubbed over each part of the hat, with the assistance of the brush, smooths and gives it a gloss. The hat is then lined and trimmed for sale. These latter operations are performed for the most part by women.

THE END.

Printed by R. Gilbert, St. John's Square, Clerkenwell.