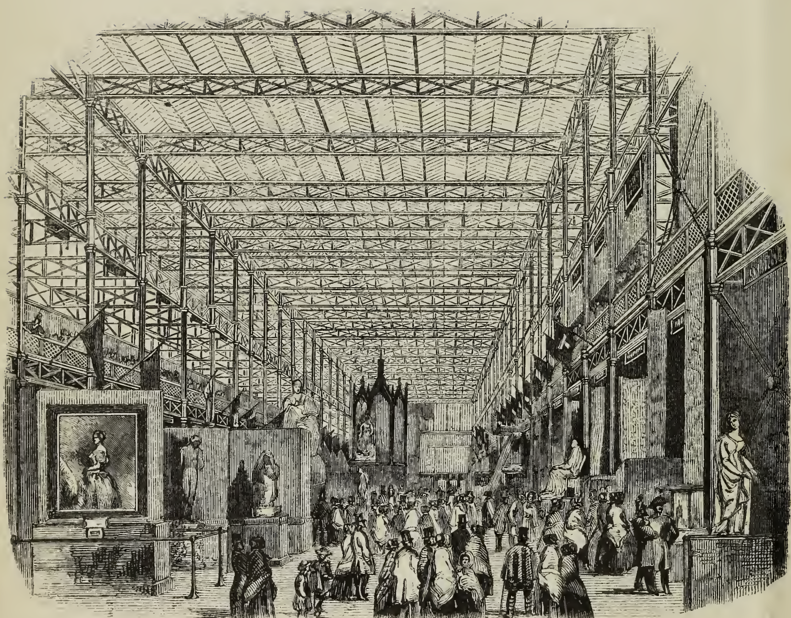

MAIN AVENUE, EAST.

THE

INDUSTRY OF NATIONS,

AS EXEMPLIFIED IN

THE GREAT EXHIBITION OF 1851.

THE MATERIALS OF INDUSTRY.

PUBLISHED UNDER THE DIRECTION OF
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APPOINTED BY THE SOCIETY FOR PROMOTING
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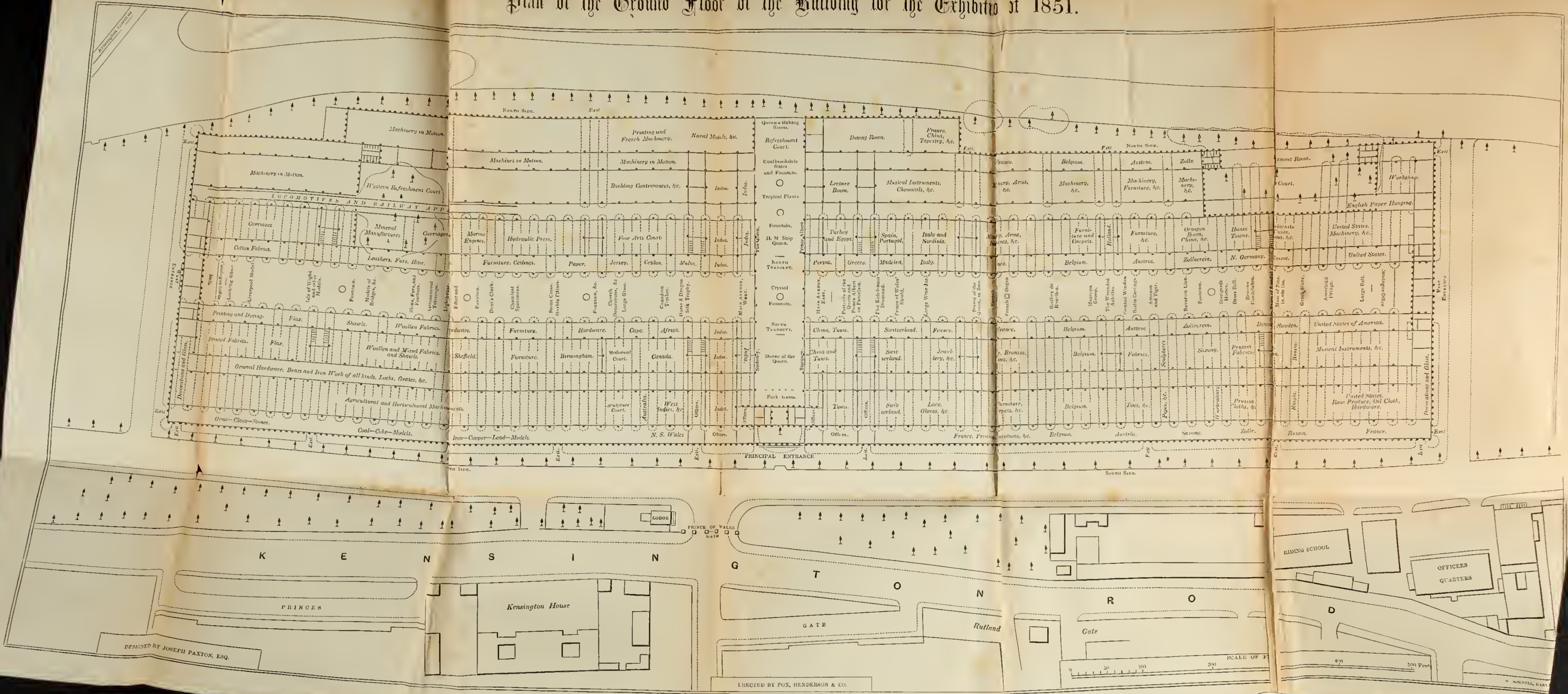
Plan of the Ground Floor of the Building for the Exhibition of 1851.



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INDUSTRY OF NATIONS.

CHAPTER I.

INTRODUCTORY REMARKS.

THE attention claimed by Industry in the present age constitutes one of its marked and characteristic features. The labours of the mechanic and artizan, for a long time considered little deserving of notice, have been found to possess a new and important interest, and to be capable of affording much material for instruction. Few persons, until of late, appear to have recognised the existence of a fund of profitable knowledge, stored by the experience of many years, in those arts and departments of labour which minister to the daily wants of society. The result of industrial pursuits, in the manufactured article, alone occupied attention, and the inquiry appears scarcely to have been made, as to the processes by which such a result was attained. The wearer of a woven fabric, for instance, was occupied only with its adaptation to the purposes for which it was procured; and the thought of the science and experience and capital necessary to its production was seldom awakened. It appears as though some indignity had been connected with mechanical and industrial pursuits, rendering a study of their interesting phenomena, processes, and products less agreeable than other subjects of investigation.

It is, however, remarkable that at a period long antecedent to our own, a truly philosophic mind had recognised that of which we have been so long negligent. A forgotten essay of the great Christian philosopher, Robert Boyle, still exists among his works, in which the dignity, value, and scientific interest of industrial pursuits are in a singular manner represented. This essay is a description of the benefits likely to ensue from the "Naturalist's (in other words the philosopher's) insight into trades." It contains some striking instances of the mutual benefits which might arise from a wider diffusion of the knowledge gained by the mechanic, and from the infusion into his practice of the principles discovered by philosophy. He remarks with justice that much may be learned about the properties of matters in the workshop of the artizan, which is pased over in silence by the most famous books. He states as an example, that he learned more about the structure and peculiarities of stones,—the raw materials of industry, by conversing with a few masons of his acquaintance, than he could ever gather from the works of Aristotle and Pliny. Care is also taken to show that by such an intercourse of the practical with the philosophical mind, the pursuits of the mechanic may receive a wonderful acquisition of power and intelligence. Boyle's desire for the scientific improvement and extension of industrial pursuits, at that period of awakening intelligence, was scarcely capable of assuming a definite and practical shape. But it appeared to him that to prepare a "History of Trades," in which the observations and practices of different trades might be united into one body of collections, would draw the attention of philosophers to the interests of industry, and of artizans to the benefits promised by philosophy. "I look upon such a book," he writes, "as one of the best means to give experimental learning both growth and fertility, and likely to prove to natural philosophy what a rich compost is to trees, which it mightily helps both to grow fair and strong, and to bear much fruit." Such a work was not written; and until a more recent period the store of facts gained in the pursuit of industrial occupations was confined to the acquaintance of those who were occupied therein.

The remarkable progress in both science and the arts, made during the last half century, has been instrumental in effecting a great change in public opinion, and in the removal of a variety of obstacles to the combination of philosophy with industry. It has been found, that the interchange of facts between theoretical and practical men has been attended with a large degree of mutual improvement, and with many benefits both to labour and to knowledge. And for a considerable period a very large amount of scientific knowledge has been employed in industrial occupations, until it has become actually indispensable to their successful prosecution. The skilled labour of the mechanic receives now the direction of mathematical knowledge, and the combinations of the manufacturer the sure indications pointed out by chemical laws. Experimental knowledge has, in a great degree, replaced the erroneous and often unproductive description of knowledge taught by a long but unenlightened experience.

The result of the combination of philosophy with industry has been to enlarge and ennoble the latter; and it has also directly tended to the advancement of the former. It is consequently found that a vast store of instruction, and that of a high description and of great interest, is to be found in connection with the occupations of the mechanic and artizan of every department of labour. To this and to the intrinsic importance of the subject may be attributed much of the growing interest taken in it.

But it is also probable that the exhibitions of works of industry of various kinds, which have been held at various times and in different places, have largely assisted to create and sustain the interest thus felt in the labours of the humbler classes. It may therefore be considered advisable to append to this work some account of the exhibitions to which the events of our day have communicated a sort of historical value.

CHAPTER II.

HISTORY OF EXHIBITIONS OF INDUSTRIAL PRODUCTS.

The great event which occupied so large a share of public attention in the year 1851, has contributed a degree of historical interest to similar displays held on previous occasions. It is often difficult, if not absolutely impossible, to assign a precise origin to an idea, the unexpected development of which has largely excited public attention. But on analysis it is almost invariably discovered that it had its period of infancy and gradual growth, and appeared not in the world as a sudden thing. It is highly remarkable, that great events have thus, as a constant rule, their time of maturation. And it is only when some unexpected circumstances combine to give them, when nearly mature, a certain degree of momentum, that they appear to start into public prominence. Every great discovery is characterized by this peculiarity; and it is deserving of strict attention, that a gleam of those great facts, which render modern science what it is, was caught by several philosophers living in the darkness of the middle ages. It appears as though human knowledge could reach no great height at one step. Time, thought, and patient labour must be the precedents of every great attainment.

These remarks are illustrated in a remarkable manner in the history of exhibitions of the products of industry. Just as is frequently the case in science, it is often difficult, if not impossible, to assign to any particular individual the honour due to a discoverer, so it appears to be a subject of doubt in the present instance, to what nation is to be attributed the merit of originating these displays. And if it were a question of individual merit, it becomes still more difficult, as there appears to be no reasonable doubt that several persons present equal claims in their origination. It may be useful to enter, without any minute detail, into a simple and impartial account of this portion of our present subject, more especially as such an historical record is not to be found in works readily accessible.

The general advancement of knowledge, consequent upon the introduction of experimental investigation as a principle of philosophical progress, a fact with which the name of Lord Bacon must always be associated, appears to have directed the attention of some observers to the real importance of even the humblest department of industry. It has already been noticed, in particular of the Hon. Robert Boyle, that his thoughts had long been occupied with the subject; and in the third volume of the folio edition of his work, is a paper having the following title, "That the Goods of Mankind may be much Increased by the Naturalist's Insight into Trades." This paper contains, as we have before remarked, the first attempt at a philosophical recognition of the value and importance of the industrial arts of mankind. In it we recognise the early effort of a man of science seeking to call the attention of the learned and great of his time to what he aptly denominates the Natural History of Trades. He contends that the benefit accruing from such an inquiry would be mutual, both to the learned in natural knowledge, and to the skilled in industrial art. And he illustrates this position by stating the following general principles. The phenomena afforded by trade, are (most of them) a part of the history of Nature, and therefore may both challenge the naturalist's curiosity and add to his knowledge. Nor will it, he adds, justify learned men in the neglect and contempt of this part of natural history, that the men from whom it must be learned are illiterate mechanics, and the things which are exhibited are works of Art and not of Nature. He pleads further for the attention of the philosophers to the productions of their humbler countrymen, by reminding them that many of the phenomena of trades are not only parts of the history of Nature, but some of them may be reckoned among its more noble and useful parts, "for they show us *Nature in motion*,—the most instructive condition in which we can behold her."

It is evident from these facts that the products of industry were felt to be of importance even to philosophy: but the period in which Boyle lived was one in which private investigation was calculated to be more useful than public exhibition, as knowledge of every kind was at that time almost in its infancy.

The formation of museums may perhaps be taken as representing the earliest instances of exhibitions of natural produce, or of curious art. The following account of these collections by the present writer, (which has appeared in another place,) will convey some conception of their general character.

"The most famous in London was at South Lambeth, and formed by the Tradescants. This museum was bequeathed to Ashmole, who bequeathed it to the University of Oxford, where it forms a portion of what is still called the Ashmolean Museum. Its collectors were in many respects remarkable men, having an extraordinary passion for the preservation and accumulation of 'rarities' of all kinds, and every place in Christendom and abroad was ransacked to supply its quota of things wonderful to the collection; and assuredly the museum contained rarities of no common order. The head of the dodo, that mysterious extinct bird, is contained therein; 'also, divers sortes of egges from Turkie—one given for a dragon's egge; two feathers of the Phœnix tayle; the claw of the bird rocke, who, as authors report, is *able to trusse an elephant;* dodar from the island of Mauritius—it is not able to flie, being so big; birds of paradise, some with, some without legges.' Among animal wonders were a hippopotamus, a salamander, a natural dragon, about two inches long, and—a 'cowe's tayle from Arabia!' Perhaps the most remarkable and interesting entry next to that of the dodo is the following:—'The plyable mazar-wood, being warmed in water, will work to any form.' There can scarcely be a question that this was in reality a small specimen of gutta percha, whose discovery and introduction into our own country is generally considered to have taken place within the last five or six years. Another famous museum was one collected by a Mr. Robert Hubert, 'and dayly to be seen at the place called the Minster-house at the Mitre, near the west end of St. Paul's Church.' Bishop Wilkins had also a museum full of curiosities. Several coffee-houses and places of entertainment in London had museums of a similar kind. One of the most celebrated of this kind was Don Salter's Museum. This Don had been a *ci-devant* servant of Sir Hans Sloane, who furnished his museum with many of its most attractive curiosities. The following is the whimsical title of his catalogue:—'A Catalogue of Rarities. To be seen at Don Salter's Coffee-house in Chelsea; to which is added a complete list of the donors thereof. Price Twopence. O Rare!' The Royal Society now also began to form its museum. In a little time a very handsome collection of natural things was got together, and fresh accessions to the museum were continually being made. A separate apartment in Gresham College was dedicated to the reception and preservation of these curiosities. Some of these are extremely curious. Sir Robert Moray presented the stones taken out of Lord Balcarres's heart in a silver box, and a bottle full of *stag's tears!* Great curiosity was excited by the arrival of the tooth of a giant, with a consignment of a few of his bones, from America! The tooth had been sold for a gill of rum, and the bones had been procured by digging near the place where the former was found. This notice has its interest to the geologist, showing how little was known of the study of fossil comparative anatomy.

"It may appear trifling to advert to such a circumstance as the formation of these museums; but it will not be so considered when we view the disposition to their collection as evidencing the spirit of the times. Such museums were an indispensable element in favouring the progress of the new philosophy. They afforded a perpetual standing testimony to which authority might appeal and the inquirer proceed for the satisfaction of his mind as to truth. Just as the old philosophy dealt with names, the new philosophy dealt with things; and it was necessary to preserve things described as a test of the truth and accuracy of their description. And it is unquestionable that such museums have assisted much in the instruction of all inquirers into natural knowledge—in giving stability to legitimate authority, and in communicating a state of decision to the mind respecting the things inquired after, in which it might safely repose. The value of museums in our own day is not similar, but it is equal to that of these early collections. By their means book-knowledge is confirmed, and indeed exchanged for thing-knowledge; and this may be perhaps taken as a summary of the utility of such collections."

These museums principally contained specimens illustrative of what was curious and rare; but they are interesting as representing in one form exhibitions of the materials operated on by man, and some of the results. They differ, however, from the exhibitions of more recent times, in the fact of their being of a permanent and enduring character—a distinguishing feature of the latter being their temporary nature.

It has been observed that we must look to the East for the first real Exhibition of industrial produce: to the Oriental Bazaars, within whose limited boundaries all the shops of a large city are not only collected—instead of being dispersed about the thoroughfares, as in Europe—but are arranged in divisions, or classes, according to the various trades and heads of produce. The word "Bazaar," a "market" in Persian, is used not only in Persia, but in India and Asiatic Turkey, and also in Egypt. The better kinds of bazaars are vaulted, with high brick roofs, and cupolas that admit a subdued light. These arrangements, however, chiefly depend on mere circumstances of climate. They have their passages lined on both sides with shops, uniform in appearance; the floors of which are raised above the level of the main thoroughfare; and the whole frontage, excepting only the width of the wall and pillar separating the boxes or shops from each other, is open. But the permanent character of these bazaars, and the fact that the wares exposed are exhibited exclusively for the mere purpose of sale, seem to remove them out of the same position with recent industrial exhibitions. The same observation applies to fairs, which are a sort of exhibition of works of industry, and it is familiarly known that these institutions have been in existence for many centuries, originally supplying the wants of a population without shops, and subsequently perpetuated simply by the force of custom.

Exhibitions resembling those to which this term is now, and will probably always continue, to be applied, the object of which is not commerce, but the advancement of the arts of life, have taken place only during the last century. The honour of originating these institutions has been claimed, and apparently with some reason, for the Society of Arts of London; and an anonymous writer, who has carefully investigated the subject, gives the following interesting account of the early efforts of this society. This will be read with additional interest, from the fact of the intimate connection of the same society with the greatest event of this kind ever beheld.

"In 1754, the establishment of the Society of Arts in London opened the avenues of every kind of knowledge to the middle classes. By the offer of rewards for ingenuity in machinery, in chemistry, manufactures, and in art—from the highest historical and poetical efforts down to designs for the cabinet-maker and upholsterer, the silversmith, the weaver, and the embroiderer—a collection of talent in every shape was produced annually before the numerous subscribers and their friends. An excellent rule of the society was '*never to turn foreigners or mechanics from the inspection of the collections*,' and this rendered their exhibition public and popular to the full extent that their premises allowed.

"In twenty years, up to 1766, rewards were given by the society to the amount of 23,551*l.* 18*s.* 2*d.*, besides one hundred and thirty gold medals, forty-six silver, seventeen gold palettes, and eighty-four silver ditto.

"Among samples of the various awards, were, a new construction of an arch, a diving-bell, carriages of various constructions, cranes, compass and protractor, engine for polishing glass, harpoons, hinges and locks, jacks and blocks for ships and shipbuilders; gold, silver, and iron wire-drawing; machine for planing cast iron, for dressing and thrashing corn, ditto for winnowing, new-invented hydraulic machine, a machine for laying in grounds for mezzotinto, ditto for raising up water to the upper part of houses, cider-mill, saw-mills, machines for saving the lives of men on board ships stranded on a lee-shore, ditto for fishing up goods from the bottom of the sea, a capstan of a new construction, a spiral wheel for raising water, index-balance, quadrant, time-piece, floating light, designs for furniture, ditto for weavers and for calico-printers.

"It will, perhaps, be readily admitted that these popular exhibitions of the industry and ingenuity of a country were the first serious establishment on principle; and its results appear to have led to much advancement in manufactures and commerce."

The example of this society was undoubtedly felt in some degree abroad, for it is a remarkable fact that the celebrated Jacquard, whose loom has effected as much for the production of textile fabrics of an ornamental kind, as Watt's discoveries have done in the development of the powers of steam, was first stimulated to its invention by reading of the premiums offered by the Society of Arts in London. It is a curious fact, also, that this wonderful invention was first exhibited to the public at the second public Exposition in France.

At a very early period the Royal Dublin Society for the promotion of industrial art was established, and a collection of manufactures was brought together in Dublin of the most interesting and useful character. From that time up to the present, similar exhibitions have been held triennially, and always with increased success. The vigour with which the Royal Dublin Society has pursued the enlightened object for which it was founded is unequalled, save by that of our London Society of Arts. These two societies have now, for more than a century, in conjunction with the Scotch Board of Trustees for the Encouragement of Manufactures, been actively engaged stimulating manufacturers to high achievements, and endeavouring to gather from abroad, for the benefit of the great native community, those results of experience which are accumulating for the future benefit of mankind in every country where industry is systematised. Up to 1850, the contributors to the periodical exhibitions of the Royal Dublin Society were exclusively Irish; but in that year the authorities extended their plan, and called upon foreigners to compete with their countrymen. This exhibition was the finest and most promising of the series. The committee, or jury, refer in their report with particular satisfaction to the vast extent and splendour of this exhibition; and they claim for their society the distinction of having been the first to "open their honours and prizes for competition to the manufacturers of all countries, and to invite them to meet in honourable rivalry" within the walls of their institution.

The originator of the French Expositions, the magnitude and prominence of which have always excited much public attention since their first origination, appears to have been the Marquis D'Avèze, and in 1844 this nobleman published a pamphlet, in which the real origin of these expositions in France is detailed. The following is an extract from this publication.

"In the year V. of the Republic (1797), the minister of the interior summoned me to undertake the office of Commissioner to the Manufactures of the Gobelins (tapestries), of Sèvres (china), and of the Savonnerie (carpets). I had no need to stay long in these establishments, to perceive the misery in which they were plunged. The workshops were deserted—for two years the artizans had remained in an almost starving condition; the warehouses were full of the results of their labours, and no commercial enterprise came to relieve the general embarrassment. Scarcely can I depict the effect produced upon me by such a scene; but at that moment a sudden and luminous thought presented itself to my imagination, and appeared to console me for the miseries of the present in the hopes it offered for the future. I pictured to myself in the most glowing colours, the idea of an exhibition of all the objects of industry of the national manufactures. I committed my project to paper, I detailed the mode of its execution, and prepared a report, addressed to the minister of the Interior, which was written throughout by my own hand, and delivered by me to M. Laucel, then at the head of the section of Arts and Manufactures, in whose office the document in question should still exist. My report soon received the approbation of the Minister of the Interior, M. François de Neufchateau, who commanded me to carry it into effect by every means useful and suitable to the Government.

"The *château* of St. Cloud was then uninhabited and completely unfurnished; and this appeared to me the most appropriate and eligible spot for the exposition which I had projected, and likely to invest the exhibition with all the magnificence and *éclat* so necessary to attract strangers, and to further the sale of the objects exhibited, the produce of which might mitigate the sufferings of our unhappy workmen. The *château* of St. Cloud was obtained without difficulty. I established myself there, and requested the attendance of MM. Guillamont, Duvivier, and Salmon, directors of manufactures. I explained to them the intention of the Government, and found all these gentlemen ready to further this object with zeal and activity. In a few days, by their obliging exertions, the walls of every apartment in the *château* were hung with the finest Gobelin tapestry; the floors covered with the superb carpets of the Savonnerie, which long rivalled the carpets of Turkey, and latterly have far surpassed them; the large and beautiful vases, the magnificent groups, and the exquisite pictures of Sèvres china enriched these saloons, already glowing with the *chefs d'œuvre* of Gobelins and the Savonnerie. The Chamber of Mars was converted into a receptacle for porcelain, where might be seen the most beautiful services of every kind, vases for flowers, in short, all the tasteful varieties which are originated by this incomparable manufacture. It was decided that the opening of this exposition should take place in the month of Fructidor; but previous to that time a number of distinguished persons in Paris, and many foreigners, visited the exposition, and made purchases sufficient to afford a distribution to the workmen of the different manufactures, thus yielding a little temporary relief to their necessities. The fame of this forthcoming exposition inspired the citizens of Paris with an eager desire to enjoy it as soon as possible; they anticipated with impatience the 18th Fructidor, the day fixed for public admission to St. Cloud. The courtyard was filled with elegant equipages, whose owners graced the saloons of the exposition, when, in the midst of this good company, I received an official notice from the Minister to attend him immediately, and to defer the opening of the exposition. I obeyed the mandate on the morning of the 18th. I waited on the Minister, from whom I received an order to close the *château*. Already on the walls of our city was placarded the decree of the Directory for the expulsion of the nobility, with an order for their retirement within four-and-twenty hours to a distance of at least thirty leagues from Paris, and this under pain of death. My name was in the list; and, consequently, my immediate withdrawal was imperative."

Such is the simple and graphic sketch of this first French exposition, which appears to have brought the idea to an untimely end. The following year, however, beheld its revival.

Its original promoter returning to Paris in 1798, collected an exhibition of manufactures, principally of an artistic description, which was arranged and exhibited in a large private mansion, and in the grounds attached to it. But the official exposition of the same year may be taken as the first National institution of this description as yet commenced. It was held in a large building in the Champ de Mars, and the objects rewarded were of the following description: watch and clock work, razors, files, blacklead-pencils, stoves and boilers, copper smithery and hardware, locks, planitariums, carpentry and cabinetwork, tinwork, various mills, firearms, swords, specimens of stereotype and various printing, spinning-machines and models of machines, woollen and silk cloths, cotton and silk stockings, gauzes and muslins, cotton spinning from Fonfrede, Pont-Audemir, Delaitres, &c., plain and printed cottons from the manufactory of Gramont and Barré, excellent broad-cloths, specimens of beautiful glass, stoneware in imitation of the English, porcelain from Sèvres and from the manufactures of Gerard and Dhel. Some of those from Sèvres were in imitation of Wedgwood's ware.

It was carried on under the direct auspices of Napoleon; and one of the principles which were decided on for the future expositions, thoroughly evinces the feeling entertained by that individual against the British nation. A gold medal was to be awarded to whoever should have offered the most formidable rivalry to English manufacture. It is interesting to notice that some of the most (subsequently) distinguished French manufacturers first received a recognition of their merits at this exposition. The following list of awards will sufficiently indicate this fact. "M. Breguet, whose name is European, in connexion with the improvement of watch and clock-making; Lenoir, as a mathematical instrument-maker; Didot and Herman, who exercised so direct an influence upon the improvement of printing; Dilk and Guerhard, whose painted china rivalled the beauty of that of Desarnod, described as the French Rumford; Conté, whose name is familiar to every artist, and to whom we are indebted for the application of machine-ruling to engraving; Clouet and Payen, who directed a vast chemical manufactory; and Denys de Luat (Seine-et-Oise), who exhibited cottons spun to all degrees of fineness, from the most common to No. 110.*

The next national exposition in France was held three years later, and was held in the Quadrangle of the Louvre. The number of exhibitors was double that of the preceding one. At this exposition Jacquard produced his loom, which was rewarded with a bronze medal, and a pension of 1000 francs per annum; this was afterwards increased to 6000 francs. The third national exposition took place in the following year, and was held in the same locality as its predecessor. The most remarkable feature of this event, was the progress it showed in the application of machinery and chemistry to industrial improvement. Twenty-two gold medals were distributed on this occasion. Among the prize-holders were Aubert, who exhibited his stocking-frame; Montgolfier, who sent his hydraulic ram; and Vaucanson, who produced his silk-spinning machine. This machine appears to have suggested to Jacquard the idea of the invention which has immortalized his name. An interval of four years elapsed after this, the next exposition taking place in 1806. The products exhibited on this occasion, evinced a steady and rapid progress in many of the industrial arts, and particularly in those connected with the manufactures of iron and steel. A long period then intervened, and from 1806 to 1819, no national exposition was held. On this occasion the event was held partly in commemoration of the restoration of the monarchy in France. Great improvements had taken place in the interval between this and the pre-

* M. Jullien Lemer. Manuel de l'Exposant.

ceding exposition; and some remarkable specimens of metal work, and of calico-printing, were exhibited. It is interesting also to find Jacquard among the exhibitors on this occasion. The next was held in 1823. There does not appear to have been any circumstance of peculiar importance in connection with this event. In 1827, four years later, the next took place, and exhibited a great increase in the number of exhibitors. It was observed, that the influence of the application of steam to the manufacturing arts, became evident, on this occasion, in the evenness and regularity of finish in the goods contributed. An important feature of this exposition was the purity of the raw, and the excellence of the manufactured silks. Paper, made by the continuous process, was also shown; and many improvements in the arts of cotton-printing, in metallic and mineral manufactures, and in the production of plate-glass, were illustrated. The eighth French exposition, was held in 1834. Among the principal novelties, on this occasion, were machine-printed paper hangings, elastic tissues made of caoutchouc, factitious ultramarine, the revival of the art of wood-engraving, and some fine specimens of inlaid ornamental work.

In 1839, the ninth of these events took place. The contributions of interest in this exposition were numerous, and included the following fine specimens of native silk, native nitre, marble from the Pyrenees, lithographic stones, discovered in France, stearine for candles, wool of the finest kind, and iron ores. Among machinery, were steam-engines, beautiful Jacquard looms, endless paper machines, chronometers, well-boring instruments, wool and cotton spinning apparatus, and sawing and planing machines. In manufactures, remarkable progress was evinced in those of leather, glass, steel, &c., and many improvements were also observed in the arts of lithography and wood-engraving. The building covered altogether an area of 16,500 square metres, and was placed in the great square of the Champs Elysées.

The tenth exposition, held in 1844, exhibited a most remarkable improvement on all the others, due, no doubt, to the encouragement of a long-continued succession of peace and national tranquillity. The contents were infinitely varied. The building was very capacious, and occupied the same site as the preceding. It was erected in the surprisingly short space of seventy days.

The last French exposition was held in 1849. In every respect it was greatly superior to those which had preceded it. The edifice in which it was contained was of immense dimensions. It was situated in the Carrè de Marigny, near the main avenue of the Champs Elysées. The area covered by it was about 220,000 square feet. In shape it was rectangular; its length rather more than twice its breadth. Round the outline of the parallelogram which it formed, was a gallery, about ninety feet wide, divided into two avenues by a double range of pilasters. In the centre of each avenue was a set of stalls placed back to back, for the exhibition of merchandise. Two transverse galleries divided this immense building, and by this means three court-yards were formed. The central one of these, which was about 140 feet square, was open to the sky, and was very tastefully decorated. In the centre an elegant fountain was placed on a platform of turf, around which flowers and horticultural implements were arranged. In one of the lateral court-yards was an immense reservoir, intended for the reception of the drainage from the roofs, and forming a supply of water in the event of a fire originating in the building. Attached to the building was a vast shed, for the display of agricultural produce and stock. The architectural character of the building, though necessarily impressive, from its very size and extent, was not pure or effective. There was much false and meretricious ornament in its external and internal arrangement. Nearly 45,000 pieces of timber, and 4,000 tons of zinc, with which the roof was covered, were employed in its construction. The total cost, inclusive of the additional structure occupied by the agricultural exhibition, was not less than about 18,000*l.*, or about 1*s.* 2⅔*d.* per square foot English. The number of exhibitors amounted to 4,494.

These exhibitions, although imitated in other countries, have never, until recently, been surpassed in splendour or extent. They have exercised an improving influence upon the French manufacturers, and that their results have not been even more striking than they are, must be attributed rather to the unsettled condition of every political and commercial relation in the affairs of that great but unfortunate country. Exhibitions of a somewhat similar character have also been held in Belgium, Spain, Germany, and Austria. Occasionally also these institutions have been established in Italy, Sweden, and Russia.

Reverting again to the industrial exhibitions of this kingdom: it is interesting to observe the fact, that agreeably to the characteristic spirit of the nation, these institutions have, in no instance, sought or obtained the assistance or patronage of the Government. In other countries they have had an exclusively national character, being identified with the proceedings of the reigning powers, but, in our own, they have been, from the first, of private origin and development, and owe their success to individuals, and not to the co-operation of the ruling powers, which, while recognising their importance and utility, have not appeared to consider it advantageous to give to them the character of national undertakings.

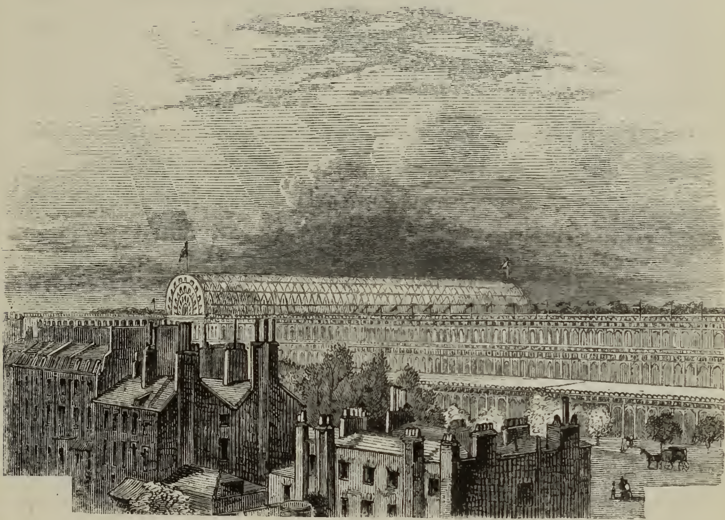
Local exhibitions of industrial products in England, as in Ireland, have been held since the period when institutes for mechanics and others have been established. Perhaps one of the earliest in England was held at Manchester, where, in connection with the Mechanics' Institute, an exhibition was opened, comprising objects in the useful and fine arts, mechanism, and practical science. Similar exhibitions were formed in other places, and under the patronage of various scientific, literary, and mercantile societies. Several of these were on a large scale, but their character was the same, and the nature of the products shown very similar also. The Society of Arts, in particular, contributed largely to the promotion of this object. By the influence of its exalted President, and of its members, much was done to create an interest on the subject on the part of the public generally, and not less on that of the manufacturing and producing part of it. The premiums awarded by this Society for improvements in the arts, and especially in those relating to the appliances of domestic life, have given a laudable stimulus to the manufacturer, and have indirectly led to an improved state of public taste in the productions of industry. But especially the exhibitions held at the rooms of this Society, of the products of modern and medieval industry, have prepared the public mind for one of a more extensive kind, and hence, unquestionably, in a great degree excited that desire for its formation which has diffused itself with the genuine character of a public enthusiasm, not only over Great Britain, but to the far and wide-spread dependencies of this immense empire.

The origin of the Great Exhibition of 1851 may be described in a few words. About the close of the year 1848, the great idea of collecting together in one great structure in the metropolis the industrial productions, not of a province or nation, but of every nation, originated, and was subsequently proposed to the Society of Arts by the illustrious consort of our beloved Queen. The most warm and enthusiastic reception was given to the proposition of the Prince Albert, and preliminary arrangements for the formation of the Exhibition were shortly commenced. The subject, which, in various shapes, had occupied the minds of many eminent men, but always seemed to present obstacles too immense to be overcome, now began to wear another form, and was seriously entertained as a practicable undertaking. Among other important means employed to set forward the proposed object, a number of public meetings were convened, which were attended by large numbers of influential persons, and were followed by energetic exertions in the formation of local committees, and in the organization of the plans then published. In the metropolis, and in every great city and town in Great Britain, similar meetings were held, and the proposal of the Prince was adopted, with earnest pledges to insure its successful issue. The Central Commission, presided over by His Royal Highness, was incessant in its labours, and a definite scheme for the completion of the great work thus commenced was finally decided on. At first the whole undertaking had been contracted for by the Messrs. Munday, but subsequently, with their consent, it was decided to rest entirely upon the nation for the support and final completion of a proposal having, as it was stated, national benefit for its end. Many difficulties presented themselves as the proposal was attempted to be realized, and not the least was the selection of a suitable site for the building. After an elaborate investigation of many projected situations for it, in or near the metropolis, the commissioners finally decided upon the adoption of a site in Hyde Park; and by all who will attentively consider its position, the nature and character of the ground, its ready accessibility, and the many advantages which it naturally possesses, it will be considered to be the most appropriate spot that could have been chosen in the vicinity of London.

When it is considered that the Exhibition of 1851 was the largest ever proposed, and, in addition, that it was the first on an extensive scale held in this country, the difficulties which attended its progress, development, and completion, may be, to some extent, conjectured. Two circumstances in its history lead us to what may greatly be considered, under Divine Providence, as chiefly instrumental to its acceptability, the first of these being the fact of its having publicly originated with that illustrious person whose happy union with our sovereign, and whose public example and character have won the suffrages and admiration of this great people ; and the next, the eminent commercial position of England in relation to every portion of the habitable globe. Deprived of such an origin, or originating in any country but our own, this exhibition could never have progressed, at least in its original form, to a successful completion.

It remains only for us to show what have been the results hitherto effected by exhibitions of united industrial art, and what may be expected from the past great event of 1851. The annals of French industry teach the instructive lesson, that from the period when the public exhibitions of that nation were commenced, down to the present time, there has been a continual progress in the application of art to industry; and, as a natural result, it has arisen, that in that country the products of the humblest mechanic always exhibit a feeling towards the beautiful in design, however imperfectly that feeling may be expressed in particular instances. Objects of daily and universal use are not, as they have been with ourselves, too little thought of to be deemed worthy of elegance of form; and the last great Exposition proved in a remarkable degree to what an extent this art-education had been diffused. "Evidence is exhibited on all hands," observes Mr. Wyatt, "of the extent to which the education of the workmen of France has been carried; scarcely ever do we recognise a piece of bad ornamental modelling; when the human figure is introduced it is rarely ignorantly drawn. In the departments of manufacture requiring tender manipulation, such as the more delicate articles of jewellery, carving, tooling, &c., we recognise a practical hand acting in unison with an ever thoughtful head. Everything seems produced, to a certain extent, *con amore*." While thus there has been progress in art, by its application to industry, it may also be made evident, that the cause of industry has been equally benefited. An important proof of this is to be found in the universal testimony of the industrial classes themselves in favour of such exhibitions. Had the exhibitors found any other than benefit to arise from the exposition of their articles, it is inconceivable that they would have exhibited a constant increase in numbers, a fact incontestably demonstrated by the returns of the eleven French Expositions. And all classes of persons agree in declaring, that these institutions have been productive of much benefit to the country in which they were held, whether in France, Belgium, Austria, Bavaria, Russia, or elsewhere. That in France, art has profited to a greater extent than industry, is, perhaps, true, for it is a natural occurrence with an ardent and enthusiastic people for the beautiful to be too eagerly pursued to the neglect of the useful; and it is to be remembered, that the success and extent of a country's manufactures largely depend upon the solidity and permanence of its civil institutions.

CHAPTER III.



THE GREAT EXHIBITION BUILDING.

SHORTLY after the determination of a site for the Great Exhibition Building in Hyde Park, the attention of the royal commissioners was directed to the important subject of the nature of the building intended to contain and display the industrial products of many nations. Several interesting circumstances mark this portion of the history of that great event. The almost universal and growing interest felt in the subject, appeared to render it probable that architects would gladly lend their gratuitous assistance in the preparation of plans, &c., for such a structure as was required. A committee appointed by the Royal Commissioners was consequently authorized to invite such aid. This was effected by the publication and extensive circulation of an invitation to architects and others of different countries, to send in designs for a building suitable for the purpose in view.

The general considerations in the preparation of designs for this structure, were the following:—The provisional nature and temporary character of the structure. The advisability of constructing it as far as possible in such a form as to be available, with the least sacrifice of labour and material, for other purposes, as soon as its original one shall have been fulfilled, thus insuring a minimum ultimate cost, and lastly extreme simplicity, demanded by the short time in which the work must be completed. The building also required to be of such a character as would admit of its being extended or curtailed, without destroying its symmetry as a whole, since it was impossible to furnish a precise idea of the extent of roofing necessary. All the arrangements for offices, spaces for relieving the circulation of the crowd, with free ingress and egress at a number of different points, also required to be attended to in this design. It was also considered expedient, if possible, to render the building fire-proof. These circumstances are all interesting when viewed in their relation to the design of that extraordinary structure which was ultimately erected.

A large number of architects competed for the honour of being the producers of the plan for the Great Exhibition building. The number of designs sent to the Royal Commission amounted to no less than two hundred and thirty-three. Of these, about one sixth were contributed by foreign architects, France sending twenty-seven, Holland three, Belgium two, and Hanover, Hamburgh, Naples, Switzerland, and Prussia each, one. It is remarkable that out of the eighteen designs which were considered as eminently meritorious, fifteen were the contributions of foreign, and only three of British architects. None of these designs, however, was adopted.

The issue of the labours of the Building Committee was the adoption of a plan of their own. And for some time extensive arrangements were prepared with a view to its being effectually carried out into practice. The exact character of the building thus decided upon may be gathered from the following features. The whole construction was reduced to cast-iron columns supporting the lightest form of iron roof in long unbroken lines. In order that the building might afford, at least in one point, a grandeur not incommensurate with the occasion, it was proposed by a dome of light sheet iron, 200 feet in diameter, to produce an effect at once striking and admirable. This vast dome it was proposed to light mainly from one circle of light in its centre. It was also proposed to exhibit stained glass in the dome. The cupola was to rise to a height of more than 160 feet, considerably exceeding in its span that of St. Peter's at Rome, and still more so that of St. Paul's in London. There was to have been a pent roof projecting along the principal front, and at the ends of the building, so as to enable visitors to be set down under cover in bad weather. The water was to be conveyed from the roof (as in the present instance) by the hollow iron columns supporting it. The reception of this plan was most unfavourable, and for a time the whole undertaking was in peril of being thrown to the ground. The enormous quantities of brickwork required would, it was quickly considered, altogether ruin the park for future purposes, and the impossibility of its being thoroughly dry before the period when it was required for use, was also seriously considered. Although in many respects an appropriate and simple structure for the end designed, many serious objections were raised to its erection; and to the proposed site. And there can be little question that had it been carried out, the result would have, in a considerable degree, interfered with the popularity, and, consequently, the success of the Great Exhibition.

Matters were in this state, when a remarkable circumstance occurred, which changed the entire aspect of the undertaking. Mr. Paxton, the nature of whose occupations had long directed his thoughts to the construction of light, simple, and extensive buildings for the reception and preservation of plants, conceived the idea of constructing a large building on the principle of a conservatory, and adapting it to the required purpose of an industrial palace. The suddenness with which the idea assumed a practical form is very singular. Its author, while presiding at a railway committee on the 18th of June, sketched out his design on a large sheet of blotting paper.* The whole of the night was spent in carrying out the design, until it assumed a complete and definite form. It took ten days, however, to complete the elevations, sections, working details, and specifications. The design was then submitted to the building committee as an improvement upon their own, but could not at first be entertained by them. It was then published in an illustrated weekly paper, and immediately its simplicity and beauty rendered it universally popular. But the cost of its execution was still to be learned. An interesting account of the manner in which this was practically carried out is subjoined: the account is extracted from a weekly periodical of the day.

"Before an approximate estimate of expense could be formed, the great glass manufacturers and iron masters of the north had to be consulted. It was now

* It is an interesting fact that this sheet was afterwards exhibited in the Fine Arts Court of the Great Exhibition.

Saturday, and only a few days more were allowed for receiving tenders. But in a country of electric telegraphs and of indomitable energy, time and difficulties are annihilated; and it is not the least of the marvels wrought in connexion with the great edifice, that by aid of railway-parcels and the electric telegraph, not only did all the gentlemen summoned out of Warwickshire and Staffordshire, appear on Monday morning at Messrs. Fox and Henderson's office in Spring Gardens, London, to contribute their several estimates to the tender for the whole, but within a week the contractors had prepared every detailed working, drawing, and had calculated the cost of every pound of iron, of every inch of wood, and of every pane of glass.

"There is no one circumstance in the history of the manufacturing enterprise of the English nation which places in so strong a light as this, its boundless resources in materials, to say nothing of the arithmetical skill in computing at what cost, and in how short a time those materials could be converted to a special purpose. What was done in those few days? Two parties in London, relying on the accuracy and good faith of certain iron masters, glass workers, in the provinces, and of one master carpenter in London, bound themselves for a certain sum of money, and in the course of some four months, to cover 18 acres of ground with a building upwards of a third of a mile long, and some 450 feet broad. In order to do this, the glass-maker promised to supply, in the required time, 900,000 square feet of glass, (weighing more than 400 tons,) in separate panes, and these the largest that ever were made of sheet glass, each being 49 inches long. The iron-master passed his word in like manner to cast in due time, three thousand three hundred iron columns, varying from 14½ feet to 20 feet in length; 34 *miles* of guttering tube to join every individual column together under the ground; two thousand two hundred and twenty-four girders, besides eleven hundred and twenty-eight bearers for supporting galleries. The carpenter undertook to get ready within the specified period, 205 miles of sash-bar, flooring for an area of 33,000,000 of cubic feet, besides enormous quantities of wooden walling and partition."

These statements vary only to a trifling extent from the real facts of this interesting circumstance. And it is extremely deserving of notice, that in the estimates prepared in such haste and formally tendered, a very trifling error would have been attended with most serious loss to the contracting parties. Unquestionably the simple fact that one square, 24 feet long, with its roof and columns, presenting a type of the whole structure (excepting the transept), rendered such a calculation infinitely more easy and certain than it would otherwise have been.

It is now familiarly known that the design thus suddenly conceived and hastily prepared, was finally accepted, and the contract for its execution was undertaken by Messrs. Fox and Henderson. It is, however, very necessary to observe, that although the design was thus rapidly conceived and executed, it is in reality only an extension of certain principles of construction long before in extensive employment. The novelty consisted rather in the application of a great conservatory to the purpose of an industrial exhibition building, than in the building itself, excepting in the less material point of its enormous dimensions. A building almost identically similar already existed in Chatsworth, only on a small scale. It is also deserving of passing remark that a structure of iron and glass had been proposed in one of the original designs sent in for competition. The extreme simplicity of the building proposed by Mr. Paxton, the facility with which it could be increased or curtailed, its lightness, dryness, facility of ventilation, and the grandeur of its interior, visible at once in all its extent from various points of view; these circumstances, added to its beautiful adaptation to the purpose of displaying industrial productions of every kind, gave to the palace of glass a degree of public interest which insured the popularity and success of the undertaking with which it had become connected.

It will be of historical interest to trace the various steps by which the distinguishing features of this structure were developed. These have been given in simple language by the architect himself in a lecture delivered before the Society of Arts, in November 1850. A few portions of this lecture may be here inserted, which will tend to elucidate the growth of those principles of construction of which the present Exhibition building presents so striking an illustration.

"The great industrial building was not the production of a momentary consideration of the subject. Its peculiar construction in cast-iron and glass, together with the manner of forming the vast roof, is the result of much experience in the erection of buildings of a similar kind, although on a smaller scale, which has gradually developed itself through a series of years. In giving, therefore, a description of the building itself, it may not be uninteresting to give a brief account of the reasons which led me to investigate the subject of glass roofs and glass structures generally, and which have resulted in the Exhibition building. In 1828, when I first turned my attention to the building and improvement of glass structures, the various forcing-houses at Chatsworth, as at other places, were formed of coarse thick glass and heavy woodwork, which rendered the roofs dark and gloomy, and on this account very ill suited for the purposes they were intended to answer. My first object was to remove this evil; and, in order to accomplish it, I lightened the rafters and sash-bars, by bevelling off their sides, and some houses which were afterwards built in this manner proved very satisfactory. I also at this time contrived a light sash-bar having a groove for the reception of the glass; this groove completely obviated a disadvantage connected with the old mode of glazing, namely, the putty becoming continually displaced by the sun, frost, and rain after the sashes had been made for a short time, and the wet by this means finding its way betwixt the glass and the wood, and producing a continual drip in rainy weather.

"In the construction of glass-houses requiring much light, there always appeared to me one important objection, which no person seemed to have taken up or obviated. It was this:—In plain lean-to, or shed roofs, the morning and evening sun, which is on many accounts of the greatest importance to forcing fruits, presented its direct rays at a low angle, and consequently very obliquely to the glass. At those periods most of the rays of light and heat were obstructed by the position of the glass and heavy rafters, so that a considerable portion of time was lost both morning and evening; it consequently became evident that a system by which the glass would be more at right angles to the morning and evening rays of the sun would obviate the difficulty and remove the obstruction to rays of light entering the house at an early and late hour of the day. This led me to the adoption of the ridge and furrow principle for glass-roofs, which places the glass in such a position that the rays of light in the mornings and evenings enter the house without obstruction and present themselves more perpendicularly to the glass at those times when they are the least powerful; whereas, at mid-day, when they are most powerful, they present themselves more obliquely to the glass. Having had this principle fully fixed in my mind, and being convinced of its importance, I constructed a pine-house in 1833 as an experiment, which still exists unimpaired, and has been found fully to answer the purpose.

"Having in contemplation the erection of the great conservatory in its present form, it was determined in 1836 to erect a new curvilinear hothouse, 60 feet in length, and 26 feet in width, with the elliptical roof on the ridge and furrow principle, to be constructed entirely of wood, for the purpose of exhibiting how roofs of this kind could be supported. The plan adopted was this,—the curved rafters were composed of several boards securely nailed togther on templets of wood, cut to the exact curve; by this means a strength and firmness were obtained sufficient to support an enormous weight. This house was subsequently fitted up for the Victoria Regia.

"In 1837 the foundations of the great conservatory were commenced, and in constructing so great a building it was found desirable to contrive some means for abridging the great amount of manual labour that would be required in making the immense number of sashbars requisite for the purpose. Accordingly I visited all the great workshops in London, Manchester, and Birmingham, to see if anything had been invented that would afford the facilities I required. The only apparatus met with was a grooving machine, which I had at once connected with a steam-engine at Chatsworth, and which was subsequently so improved as to make the sash-bar complete. For this apparatus the Society of Arts, in April, 1841, awarded me a medal, and this machine is the type from which all the sash-bar machines found in use throughout the country at the present time is taken. As the conservatory was erected under my own immediate superintendence, I am able to speak accurately as to the advantages of the machine; it has, in regard to the building alone, saved in expense, 1,400*l.* The length of each of the bars of the conservatory is 48 inches, only 1 inch shorter than those of the Exhibition building. The glass and glazing of the Chatsworth Conservatory caused me considerable thought and anxiety, as I was very desirous to do away altogether with the numerous overlaps connected with the old system of glazing with short lengths. This old method, even under the best of management, is certain in the course of a few years to render unsightly any structure, however well built. In the course of my inquiries I heard that Messrs. Chance and Co., of Birmingham, had just introduced from the continent the manufacture of sheet glass. Accordingly, I went to see them make this new article, and found they were able to manufacture it 3 feet in length. I was advised to use this glass in two lengths with one overlap, but to this I could not assent, as I observed that since they had so far advanced as to be able to produce sheets 3 feet in length, I saw no reason why they could not accomplish another foot, and if this could not be done I would decline giving the order, as at that time sheet glass was altogether an experiment for horticultural purposes. Those gentlemen, however, shortly afterwards informed me that they had one person who could make it the desired length, and, if I would give the order, they would furnish me with all that I required. It may just be remarked here, that the glass for the Exhibition building is 49 inches long, — a size which no country except England is able to furnish in any large quantity even at the present day. In 1840 the Chatsworth Conservatory was completed and planted. The whole length of this building is 277 feet, its breadth 123 feet over the walls, and the height from the floor to the highest part, 67 feet."

The flooring of the building had also long engaged the architect's attention. He says :—"I have tried many experiments in order to find out the most suitable floors for the pathways of horticultural structures. Stone is objectionable on many accounts, but chiefly on account of the moisture and damp which it retains, which renders it uncomfortable, especially to those wearing thin shoes. The difficulty of getting rid of the waste from the watering of plants is also an objection; but, perhaps, the greatest is the amount of dust from sweeping, which always proves detrimental to plants. I likewise found that close boarding for pathways was open to many of the same objections as stone; for although damp or moisture was in part got rid of, yet still there were no means of immediately getting rid of dust. These various objections led me to the adoption of trellised wooden pathways, with spaces between each board, through which, on sweeping, the dust at once disappears, and falls into the vacuity below. Whilst the accomplishment of this point was most important in plant-houses, I consider it doubly so with respect to the industrial building, where there will be such an accumulation of various articles of delicate texture and workmanship. The boards are nine inches broad, an inch and a half thick, laid half an inch apart, on sleeper joists, nine inches deep, and three inches thick, placed four feet apart. This method of flooring, then, possesses the following advantages:—It is very economical, dry, clean, pleasant to walk upon, admits of the dust falling through the spaces; and even when it requires to be thoroughly washed, the water at once disappears betwixt the openings, and the boards become almost immediately fit for visitors."

The remarks which appear at the commencement of the second chapter of this work, receive an important illustration in this unpretending history of the facts preceding the origin of the Exhibition building. The building itself, not less than the design of such an exhibition, was not of fortuitous production. In reality it might be said, that many years had been occupied in its production,—years which were spent in the development of its different portions, until the period arrived when all was prepared for the production, on the first occasion requiring it, of an edifice in every respect as wonderful as the Industrial Palace.

CHAPTER IV.

CONSTRUCTION OF THE BUILDING.*

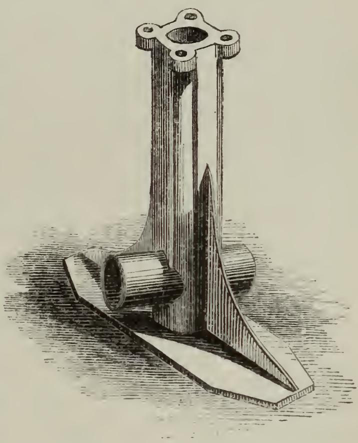
PERHAPS the best idea of the general structure of the Exhibition building is derivable from a study of a small portion of it. It has already been observed that the construction of a single portion exactly typifies that of the whole edifice, and consequently, if a right understanding is gained of this portion, the constructive details of the whole will be also readily intelligible. To a considerable extent this is true; but, in consequence of the vast dimensions of the building, and the peculiar difficulties entailed thereby upon the erectors of it, many interesting and important features

* The cut represents a very early period in the construction of the Building.

in its history relate to it as a whole, which are not applicable to that of any single part. If it had been of smaller dimensions some of the most curious facts in its history could not have been observed, since they had their origin exclusively in the enormous magnitude of the undertaking, and in the ingenious methods invented for the occasion to overcome the difficulties arising out of the immense amount of labour necessary to its erection.

In order to give a clear account of the construction of such a portion of the building, it may be well to commence with the columns; the number, position, and beautiful regularity of which, constituted one of the most striking internal features of the building they supported. The spectator of the progress of the work of erecting this building would, at an early period, have been struck with the appearance of certain holes dug at regular intervals in the green sward of the inclosure at Hyde Park. These holes were carried down to the stratum of gravel which underlies the surface soil at a depth of a few feet throughout the strip of ground occupied by the building.

They were then filled with concrete. These holes were destined for the reception of the base of the many hundred columns intended to support the building. They varied in size with the calculated pressure to which the columns they were to give support to would be subjected. It was so arranged, that under no circumstances should a pressure greater than two and a half tons per superficial foot be brought to bear upon this foundation. In due time the column would have been seen erected upon this foundation; and connected with other columns. At the base of every column on the lower story throughout the building, is a portion separate from it, and of simple but peculiar and ingenious form. This piece has been technically called the base or bed-plate. It consists of the following parts; an upright columnar portion attached to the column above, a horizontal tube attached at the bottom to drainage-pipes, and a flat horizontal plate. The horizontal plate, which was strengthened at each side by vertical shoulders, served as a firm basis to the whole piece. The horizontal tube running transversely across the long direction of the plate, was adapted to form a socket on either side of the plate, into which an iron pipe for drainage was inserted. The cut represents one of the base-plates. These pipes for drainage ran from column to column, and were securely connected to the sockets by the ordinary process of pouring in melted lead into the joint. The vertical tube being in direct communication with the transverse tube established an uninterrupted channel for the conveyance of the roof-water. At the top of the latter, four projections with holes in them were cast, by which, with the assistance of bolts and nuts, a rigid connexion with the column above was secured. Since the column was also hollow, the roof-water readily flowed down it, entered the transverse tubes, and was thence conducted into capacious drains which delivered their contents into the sewer in the Kensington Road. These base or bed-plates were placed on the concrete foundation previously prepared for them.



BASE PLATE.

Some of the labour attendant on the preparation of the materials for the erection of this building, may be estimated from the simple fact, that scarcely one of these base-plates was of a similar height. In consequence of a fall in the ground, it was necessary to adjust the height of each plate so as to counteract that circumstance, and render the base of the building level, or nearly so. Every base-plate was consequently adapted to a peculiar position, and to no other; and its height required to be made a subject of careful calculation beforehand. Not fewer than one thousand and seventy-four such pieces were necessary, and each of that vast number had its proper height and position appointed. The bearing surface of the vertical tube was made to fit accurately that of the column it was to support, by being planed perfectly flat and true, and so carefully were the base-plates laid on their concrete foundation, that these surfaces fitted with the greatest nicety, and were screwed together with no other packing than a piece of canvas dipped in white lead, which served to render the joint perfectly water-tight.

The columns, which are somewhat quadrangular in plan, were designed by Mr. Barry. Internally they are circular tubes, but externally four flat bands have been cast upon them which serve the double purpose of contributing a support for the pieces connected to the columns, and they also increase the strength of the column. These flat bands also contributed an ornamental aspect to the columns, which was rendered more conspicuous by the principle of decoration adopted, the columns being picked out in blue, white, and yellow. The columns were 8 inches in diameter, and the lower series were 18 feet 6 inches high. Their functions were to support the galleries and roof, and as drain-pipes to carry down the immense flood of water collected by the roof in wet weather. The columns were attached to the base plates below, and to a short tube above, by four projections cast at each end in the four tubes in it, which admitted of its being firmly bolted and screwed so as to retain a rigid, perpendicular position. The great strength of these apparently slender columns, which was for a considerable time a matter of doubt and anxiety to many, was strikingly illustrated by Professor Cowper in a lecture delivered in the building itself during the progress of the works. To show the strength of the pillars, slender as they appeared, he took two pieces of quill about an inch long each, and commenced heaping upon a piece of wood that rested on them a number of weights, till he had placed upon these apparently fragile columns two hundred weight when they gave way under the pressure. This simple and yet conclusive experiment as to the strength of tubular columns excited much interest among the members. He stated as a further illustration, that on a former experiment he had found that two straws would bear half a hundred weight. The hollow form of column had not been adopted without due deliberation. It was found on calculation, that of two pillars, one solid, the other hollow, the hollow pillar would bear about four times the weight of a solid one.

Connected to the columns at their upper extremity were small vertical tubes, of a simple but peculiar form, and fulfilling the highly important function of binding together, in a solid manner, the columns above and below it, and the girders laterally. These tubes were called connecting pieces. They were, in fact, short columns, having at each end projecting pieces called "snugs," which in a simple manner hooked together the top and bottom of each of the four girders connected with them. The girders were made in such a manner that at the point of connection they exactly fitted into the hooked part, and were thus firmly retained in their position by a small piece of iron which was driven in and acted as a key to the joint.

It may be readily imagined that the compound shaft thus formed of a base-plate, the column and the connecting piece, would be one, the perfect perpendicularity of which it would be very difficult to secure. To how great an extent was this difficulty increased when, as in the case of the columns supporting the transept and main avenues, the entire shaft, from top to bottom, consisted of no less than seven distinct portions, each screwed and bolted together!

In order to make sure, observes Mr. Wyatt,* that the shaft thus composed of alternate columns and connecting-pieces, should be capable of maintaining itself in a perfectly vertical position, it was necessary that the whole of the surfaces of contact should be wrought perfectly true and flat. Every column and every connecting piece had, therefore, to be placed in a lathe; and the bed or surface at each end faced to a perfectly true plane. When the number of these columns, base-plates, and connecting pieces is taken into consideration, it may be easily imagined that the labour entailed by this apparently simple necessity could scarcely have been performed in any workshops but those provided with extraordinary facilities and resources.

The assistance of a theodolite was also called into requisition, and every pillar was thus placed absolutely vertical, and the result is, that if the spectator looked all along the building, either lengthwise, or sloping, or across, every line of columns was found covering one another with the most beautiful exactitude. Indeed, if it were not so, the girders would not have fitted into their places, since they were not made in such a manner as that they could be altered if necessary, but were all prepared and fitted with the utmost precision down in the country.

The cast-iron girders form the next important part of the section of the building now under study. Their construction, like that of the other portions, is very

* Official Descriptive and Illustrated Catalogue, p. 55.

simple, and the complication presented to the eye by their immense number and peculiar connexion with the slender columns supporting them vanishes when a single member of the series is examined. These girders were all 25 feet in length, and 3 in depth. On examining a girder in its position, and looking at either from above or below, it was seen that the lower and upper flanges or tables, in other terms the top and bottom flat portions of its length, were narrow to each end, and widest in the centre. The cause of this was the necessity for throwing additional strength into the middle of the girder where the strain was the greatest. Each girder was divisible into three parts, each of which was eight feet wide. These compartments were separated by two vertical portions, at which points the pressure was the greatest. Between these points and from them to each end diagonal pieces extended, which connected and strengthened the whole. At each end of the girder a little piece of iron was cast on to it by which it readily and firmly hooked into the connecting piece and was firmly secured to it. The strength of these girders, of which there were more than two thousand in the edifice, was very great, and the breaking weight was calculated at not less than 30 tons. As each girder was carefully proved before being placed in its situation, its strength was known to be more than adequate to the demand to which it would be subjected. The process of proving the girders will fall under consideration at a future page.

The flooring supported by these girders was ingeniously arranged so as to throw the weight of each very equally on the four girders, and in such a manner as to cause it to bear upon them at the vertical points just described, where the strength of the girder was greatest. This was effected by tie-rods of wrought iron, passing through a piece of cast-iron, called a shoe, at each end, and pressing up two bearers, or "struts," which were made to support in some degree the cross-beams of timber on the under side of which they were situated. The floor was supported by joists stretching from the girders to the cross-beams, and from one of these to the other. It was about an inch and a quarter thick, and in order to prevent dust falling through it upon the goods exhibited underneath, between each joint in the floor a flat band of iron-hooping was placed, which effectually answered the desired end. A light cast-iron railing of simple design was placed at the sides of the gallery.

The following extract from Mr. Wyatt's account carries us to the roofing.

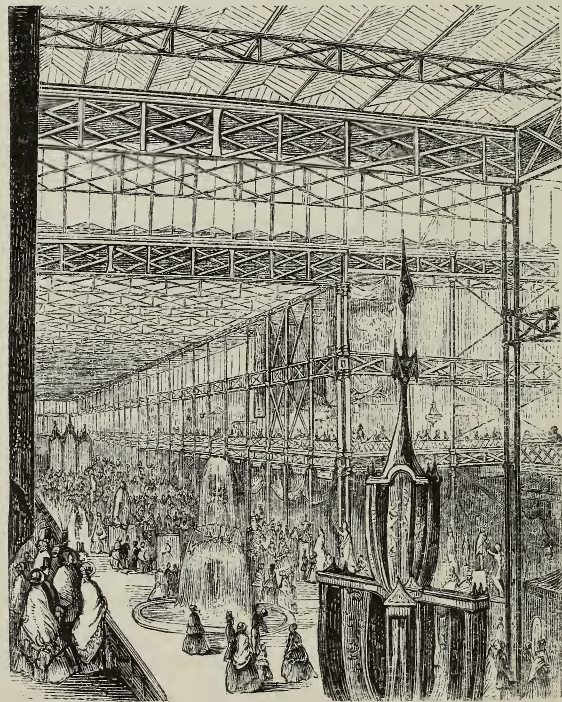
"The columns which rise at the gallery level are 16 feet, $7\frac{1}{4}$ inches long, and are surmounted by connecting pieces, similar in all respects to those occurring beneath. To these connecting pieces are attached, transversely in one direction and longitudinally in two, cast-iron girders of similar form and scantling to those we have described; their office being to maintain perfectly true and rigid, the vertical shafts which carry the eye upward in one unbroken line from the ground to the roof which they serve to support.

"As the strength of an iron column practically depends upon its length being limited, far more than upon its substance, the value of dividing the whole length of the shafts reaching from the gallery to the roof into two parts by these connecting-pieces, and thus reducing the length of the columns one-half, must be readily appreciated.

"Above the second tier of girders rise columns of the same length as those last mentioned, and on them again are placed connecting pieces, to which the girders supporting the roof are attached. These girders correspond with those supporting the galleries, and exactly resemble those forming the tier immediately beneath them, in every respect excepting their thicknesses. The whole of the girders on the upper tier have been proved in the building to a strain of 9 tons."

Before passing to the consideration of the architectural structure of the roof, if such a term may be applied to what is rather the triumph of the engineer than the architect, it is proper to notice that in addition to the cast-iron girders employed, girders of wrought-iron were also used. The girders of wrought-iron were also called trusses. They were employed in lengths for which cast-iron would have proved a very unsafe material of construction. The wrought-iron girders were intended to support the roof of the great central avenue, and also that of the avenues on either side. In order to effect this it was necessary that they should be of different dimensions, since the width of the central avenue is 72 feet, and that of the side avenues 48 feet, the latter being exactly twice, and the former three times the length of the cast-iron girders supporting the galleries. These girders were formed of longitudinal flat bands of wrought-iron, which were held together by diagonal bracings of similar bands, the top and bottom of each girder being kept asunder (or supported perpendicularly) by strong vertical pieces of cast-iron to which the diagonal bands were bolted. These were placed at intervals of 8 feet, and served to maintain the vertical position of the girders, and to give them the requisite strength and rigidity. A slightly arched form was given to these girders in order to facilitate the discharge of the roof-water. Both descriptions of girders, (the 48 and the 72 feet) were carefully proved prior to their erection, and it was found that with the weight of 10 tons the smaller girders deflected 3 inches, and the larger ones $6\frac{1}{2}$ inches with a dead weight of 16 tons; in both instances the elasticity of the girders was completely restored on the removal of the load. The remarkable effect produced in a perspective view of the central avenue by these girders must have been noticed by every person, and was only inferior to that of the numberless receding lines formed by the columns and their connections.

The entrance to the Eastern and Western divisions of the central avenue from the transept was spanned by girders also of wrought-iron, but somewhat differing



INTERSECTION OF TRANSEPT AND MAIN AVENUE.

from the preceding in its construction. These girders were 6 feet in depth, and 72 feet in length. They closely resembled in their general features of construction the others. They were rendered necessary by the circumstance that at this part the girders have to maintain the transept roof, and it was consesequently important to provide an adequate amount of support. Their greater depth and the interlacement of the diagonal bands of iron rendered them readily distinguishable from the other girders of the same length but of only half the depth. They are clearly shown in the cut on the opposite page from an actual photograph taken in the building.

The reader is now prepared to proceed from the interior to the exterior of the building, and, having examined the supports of the roofing from the ground upwards, to study the roof itself. The same simplicity of general arrangement characterized this as it did other portions of this edifice. Running from one girder to another in a transverse direction were lengths of timber hollowed out so as to form a gutter. These pieces of timber were 24 feet long, and by an ingenious plan served to convey the roof-water received by drip from without, and the condensed water arising from the deposit on the glass, within. These gutters have been called after their inventor, Mr. Paxton, and they served the double function of acting as a drain both externally and internally. On the upper surface was a capacious semicircular channel which carried off the roof-water, and on each side was a very small channel which received the drip from the glass. These gutters, of which 20 miles in length were necessary for the building,—were supported below by an iron rod running through two cast-iron bearers, by which means they were prevented from bending as they would otherwise do from their weight. The gutters were cut by an ingenious machine to which reference will be made further on. At their point of junction, a circular hollow existed, through which the water passed into a square or box-gutter below. The latter gutters were more capacious than the

Paxton gutters, and receiving the water from several of them, transmitted it down the columns, whence it passed through the base-plates into the lateral drains, and thence into the main sewer.

Attached to the shelving sides of the Paxton gutter were the sash-bars, which were secured in that position by being nailed into notches cut in the side of the gutter for their reception. In addition to these, other bars were placed at intervals of 8 feet, which formed principal rafters, but resembled the sash-bars in every respect excepting in size, being of double their thickness. These bars, as well as the sash-bars, were grooved at the sides for the admission of the panes of glass. The total length of sash-bars amounted to about 200 miles.

The glass of this building, forming its most distinctive feature, completes the roof. The panes were forty-nine inches in length, and ten in width. The glass was strong, and was of the kind known as sheet. Its manufacture must be referred to on another occasion. It may be interesting here to relate that these are the largest panes of sheet-glass yet made in England. And it is probable that in no other country could they have been produced in the necessary quantities within the time given for their manufacture.

The top of the roof, or "ridge," consisted of a piece of timber supporting on each side the sash-bars leaning against it, and the glass between them. The ridges, like the sash-bars, were cut by machinery, and vertically would have extended to about sixteen miles in a horizontal direction. The ridges were connected together in certain lengths, the ends being prepared by machinery so as exactly to correspond, and to admit of precise and simple adjustment. The entire roof was extremely light and weighed not more than about three pounds and a quarter per superficial foot on the average.

For the purpose principally of preventing leakage, and also of subduing the intensity of the light, the flat roof was covered with canvas. The canvas was attached to the ridges, and allowed to hang down between them in a festoon. As one width of canvas was insufficient to reach from ridge to ridge, two were sewn together, the seam occurring in the centre, immediately over the Paxton gutter. The rain descending fell on the canvas, and clinging to it by capillary attraction, crept down until it arrived at the seam, where it passed through the canvas, and fell into the Paxton gutter; thus the danger of the passage of water which might take place through broken panes or imperfect putty-joints, was obviated, and the chances of leakage were consequently materially diminished. The canvas also materially assisted in keeping the building cool. The high temperature of the interior on one or two occasions must again receive notice, but it would have reached a still higher point, had the canvas not been applied externally. This canvas was in fact unbleached calico, and the colour of that material being of a subdued yellow, the intensity of the light pouring into the building through its roof was greatly diminished and softened. When this canvas became filled with soot and other impurities deposited by the air, the light was too much diminished, particularly as this was observed during the later weeks of the exhibition, when the solar intensity was of course affected by the decline of the year. To such an extent was this found to exist, that the writer, who was frequently in the habit of taking photographs of the interior, and of the objects contained in the building, was ultimately compelled to desist, owing to the lengthened period of exposure necessary to obtain the photographic image. For photography on glass a period of upwards of *two hours* of exposure in the camera became necessary to produce a picture. And in the Daguerreotype, the same plates which, with ordinary diffused out-of-door light, would have received a perfect image in a few seconds, were exposed, on numberless occasions, for periods varying from half-an-hour to an hour and upwards, a period probably unheard of in Daguerreotypy.

The canvas was so fixed as to allow a current of air to pass between it and the roof. In very hot weather, water, it was suggested by Mr. Paxton, might be poured on, which would very much assist in cooling the temperature within. Provision was also to have been made to use the Indian plan of ventilation, if the heat proved so intense as to render it desirable to have the temperature cooler than out of doors. A house was fitted up at Chatsworth, as an experimental place, to try this mode of ventilating, when it was found to answer admirably. The temperature was reduced in one hour from eighty-five to seventy-eight degrees, without any other means being used to increase the draught through the building. This sort of covering offered also the advantage of protecting the glass from the possibility of injury by hail.

The sides of the building, which can scarcely be rightly called walls, since neither brick nor mortar enter into their composition, may next engage our attention. It was at first contemplated to enclose the whole of the building with glass down to within a few feet of the ground. But it was subsequently thought advisable to fill the lower interspaces between the columns with wood instead. All round the building, next the ground, were the "louvre" frames for ventilation. The following is Mr. Wyatt's account of the construction of those ventilators :—

"The ventilators fulfil an important office in the building, acting as the organs of respiration to the whole body. The total surface of ventilation is nearly 50,000 superficial feet, and the whole has been so arranged, that, by the application of one man's strength, at about ninety different points, the whole may be opened, closed, or set and secured at any desired angle, simultaneously. The ventilators themselves consist of galvanized iron blades of an S form, 6½ inches wide, fixed on pivots at 6 inches from centre to centre. Of these there are eight in the wooden frame inserted between the columns and the sill on the ground floor, and six in those which surmount the sash-frames on the two upper stories. The section of the blade is of a novel form, and is calculated, when open, to afford the minimum interruption to the passage of the air, compatible with being weather-tight at all times. To each blade, in the centre of its length, are attached small iron brackets furnished with eyes, through which pins are inserted, which pins are secured in a species of wooden rack. These racks are connected with cranks attached to iron rods, to which a movement of torsion is conveyed by screws and powerful levers. A moderate exertion of the strength of one man applied to one of these levers, suffices to regulate, with facility, no less than 600 feet superficial of ventilation."

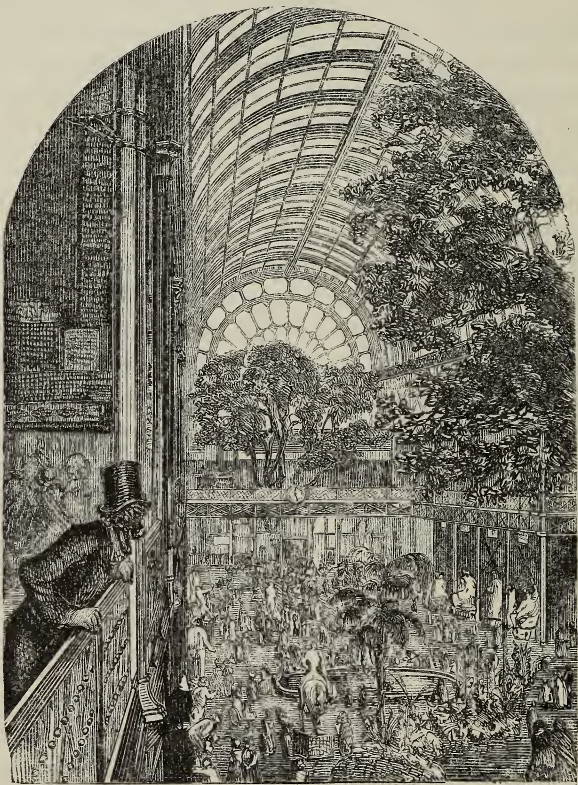
On the upper tiers glass formed the external facing. The panes, which were in every respect similar to those forming the roof, were inserted into sash-bars, which were grooved at the sides for their reception, and strengthened by rods of wrought iron. The sash-frames into which these bars were fitted, were ingeniously constructed so as to offer the best resistance to the pressure of the wind, and the whole was so arranged as to produce a connected chain of resistance to external pressure through the whole circuit of the building. A light iron casting, of an ornamental form, ran along the edge of the successive terraces, interrupted at intervals by the flag-staffs.

The transept, with its arched roof, requires a short description before concluding the present chapter on the elementary features of the construction of this edifice of iron, wood, and glass. The width of this portion of the building was seventy-two feet from side to side; but, at the sides, there were, in addition, arches twenty-four feet wide, which also required to be covered with a roof. The roof of the latter was the only portion of the roofing of this building made of a more resisting material than glass. Although twenty-four feet in width, and four hundred feet in length, this portion of untransparent roof, flanking each side of the transept, was scarcely noticed to differ from the rest, such was the magnitude of the structure, and so great the illumination of every portion of it. This part of the roof was formed of wood, covered with sheet lead, forming what is technically called a lead flat. It was a broad and delightful walk on either side of the glittering arch of the transept roof. The mode of construction adopted for this part of the roof appeared to be considered necessary, in order to receive the large volume of water descending from the transept vault, and also to serve as a solid abutment for steadying the ribs.

The semicircular vault of the transept was justly considered one of the most remarkable and interesting features of this building, and in its construction proved the most arduous and difficult part of the work. The roof was supported by ribs which were placed at intervals of twenty-four feet. Their structure has been described in the following terms:—"They are made in three thicknesses of timber, cut into segments, 9 feet 6 inches long, of a circle of 74 feet extreme diameter, the centre thickness being 4 inches by $13\frac{1}{2}$ inches, and the outer, or flitches, breaking joint with the centre, being 2 inches by $13\frac{1}{2}$ inches. The flitches are nailed to the centre thickness, and $\frac{5}{8}$ths inch bolts, about 4 feet apart, on the segment, traverse and bind together the three thicknesses. On the extrados, or outer circumference of the wooden arch thus formed, two planks serving as a gutter board, 11 inches by 1 inch, and a bar of iron 2 inches by $\frac{5}{8}$ths inch, are bent to the curve; and on the intrados, or inner circumference, a piece of timber, 7 inches by 2 inches, moulded to correspond with the form of the columns, and a bar of iron, $3\frac{1}{4}$ inches by $\frac{5}{8}$ths inch, are also bent to the curve. Bolts, at intervals of 2 feet, from centre to centre, passed through the depth of the rib, unite these additions to each other, and to the main rib, which, thus increased in scantling, measures, complete, 1 foot 6 inches by 8 inches." In order to perfectly connect these ribs, so that any force exerted, by wind or other causes, tending to the displacement of any one of them, might be distributed over the whole mass, iron rods were set diagonally, forming a complete reticulation over the whole inner surface of the roof. The main ribs were fixed spanning the transept, at intervals of 24 feet from centre to centre. Each of these 24 feet widths was divided into three parts, and at 8 feet from one another, and from the main ribs, minor ribs were introduced. Between them again, but being semicircles of larger diameter, were fixed small ribs of wood, which being connected with the main and minor ribs by means of sash-bars, became available as ridges. The space between them and the ribs was glazed and finished on the same system as that adopted in the flat roof of the building, the sash-bars being set at an oblique angle, or "herring-bone" fashion, in order to assist the conduction of the water, and prevent its lodging against the lower putty bed of each pane of glass, over which it trickles.

Along the summit of this semi-cylindrical vault ran from north to south, a narrow lead path, in order to afford access to the apex of the roof, and to provide a means of lowering down workmen to repair any damage that might possibly happen to it.

The ends of the transept were filled in by radiating timbers, which gave to them an interesting and ornamental appearance. The cut well represents this ap-



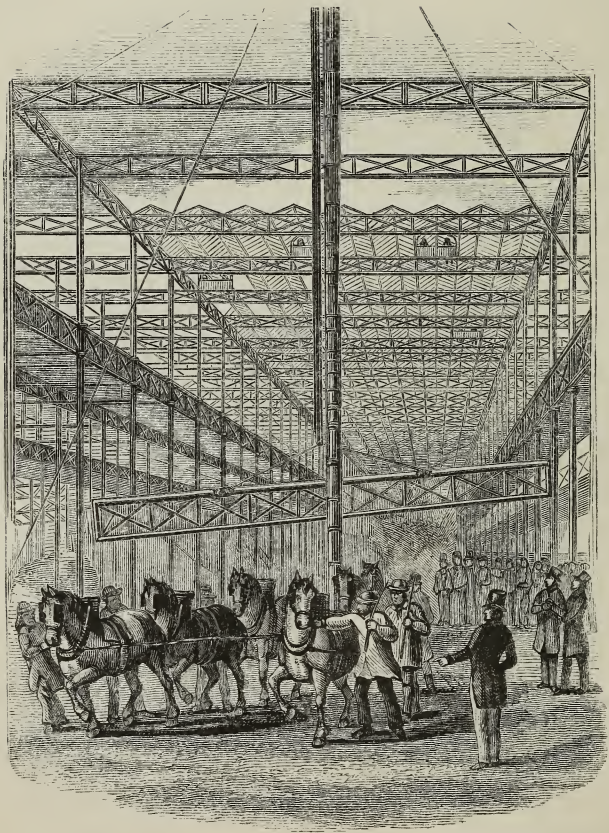
TRANSEPT LOOKING SOUTHWARD.

pearance. At the south entrance a small interspace at each of the radii, was made the convenient position for the introduction of figures representing the hours from six to six, and, in the centre, the long gilt hands of the electric clock were placed. This substitute for a dial proved, however, very unintelligible to a large number of persons always accustomed to associate the idea of a clock face with a circular disposition of figures. Both ends of the transept were filled in with sash-bars, sustaining panes of similar size to those elsewhere employed.

The columns at the four corners, at the junction of the east and west main avenues with the transept, were strengthened by an additional column, which it was considered desirable to introduce at this point, since the strain was here the greatest. In order to give additional security to this part of the structure, a system of diagonal bracing was also introduced. Wrought iron rods, a little less than an inch in diameter, passed transversely across the square formed by the two columns and the girder above. These rods met in the middle, in a cast-iron ring, where they were firmly screwed up. Considerable additional stability was thus given to the parts united together, and consequently to those in connection with them. The same method of increasing the strength of parts of the building was adopted in other places.

With this notice it is desirable to conclude the present chapter. If its contents are carefully perused, and clearly understood, the reader will be in possession of almost every fact of importance in reference to the essential structure of the Exhibition Building. A description of the entire building would not appear in place here, since it is important, at present, to confine the attention simply to the elements of construction, but, on another occasion, such an account will be given, and any of the minor details omitted here will be there presented.

CHAPTER V.



PROGRESS OF THE WORKS.*

At a very early period of the construction of the

* The cut represents the arrangement for raising one of the wrought-iron girders of the main avenue.

Exhibition building, the writer watched, with daily increasing interest, its gradual rise and progress. The earliest Daguerreotypes taken of this wonderful structure, were then taken, and remain the unerring representatives of a scene never before witnessed, nor likely again to be produced. From that period to its completion, probably few persons, not in direct connection with the undertaking, had more frequent opportunities of marking the various stages through which the edifice passed — from the erection of the first few columns to its final completion—to the accuracy of much therefore of what is contained in the present chapter, the testimony of an eye-witness can be added.

It has already been mentioned that a site in Hyde Park, near the Kensington Road, had been determined on by the commissioners appointed to report on the most eligible position for the situation of the exhibition building. This site presented many advantages, and ultimately, the wisdom of its selection was evident. The first indication of the preparations for the proposed structure, was presented in the extensive hoarding which was erected all around the site of the building. In the month of August, 1850, this hoarding was commenced, and, in a short time, the entire space intended to be occupied, was enclosed. For this purpose an immense supply of timber was necessary, since the area covered by the building was about 20 acres, and it was necessary to allow, at each extremity, a considerable space for the necessary stores, shops, &c. The hire of waste timber, for such a purpose, would have proved extremely expensive, and it was consequently decided to make use of that intended for the flooring. It was, however, necessary to avoid injuring this timber, as far as possible, and to preserve it in a state fit for use, in the manner indicated. The hoarding was constructed in the following simple and effective manner. The timbers to be afterwards used as joists were inserted into the ground perpendicularly in pairs, with a space between them. Between each pair the ends of the floor-boards were slipped, and these were secured by attaching together the two ends of the joists extending above them; no nails were consequently necessary, and board after board was thus placed, until a height of eight feet was reached, which was considered sufficient. The flat edges of the boards, resting in close contact, prevented the idle or inquisitive gathering around the hoarding, as it was impossible to obtain a glimpse of the works through the join. In this manner the whole area was enclosed, and the celerity with which it was accomplished, due in great manner to the simplicity of its structure, gave early promise of the rapidity which should characterize, at a subsequent period, the erection of the building itself.

Within the area thus enclosed, temporary offices were quickly erected. Considerable interest was attached to these, from the fact that the roofing was constructed precisely in the same manner as that of the future building. These offices were lighted by the ridge and furrow roof, glazed with the 4-feet panes before mentioned. In addition to these offices, ranges of carpenters' shops and sheds were erected, together with blacksmiths' shops, and stabling for horses, used in conveying the materials, and in other work. The green sward of Hyde Park soon began to assume a very busy and unwonted aspect; workmen were seen busy in various directions over the large area, and quantities of materials, chiefly timber, were being carried to different portions of it. At this time no columns had been placed.

The next step in the progress of the building, was what is technically called, "setting out the ground." This was, in fact, to mark out, at points equidistant from each other, the position of the columns, and also the general outline of the building. The four extreme angles of the building were first determined, and the centre lines of the main avenues. This was done in order to give certain fixed points, from which other measurements could be carried out.

In order that the measurement of 24 feet, upon which the accuracy of the whole plan depended, might be indicated with extreme precision, poles of thoroughly-seasoned pine were fitted with gun-metal cheeks, or small projecting plates, the ends of the poles extending a few inches beyond the cheeks. The measurements were taken by laying one pole on the other, so that the inner edges of the gun-metal cheeks, set at precisely 24 feet from one another, might be brought into contact. Thus the danger of any error, arising from the ends of the poles becoming damaged in use, was avoided. Stakes having been driven into the ground to indicate approximately the position of the columns, their precise centres were ascertained by the use of the theodolite, and marked by driving a nail into each stake at the exact point.

It may serve to indicate the extreme precision with which every step in the progress of the works was marked, to observe that the length of these measuring rods was determined by the standard of the Astronomical Society, and the same standard was employed in other measurements, by which a precise agreement in the dimensions of parts was obtained. It is readily conceivable that a trifling error in this portion of the work would have been attended with serious results in a building so rigid in its principles of construction, and of such extreme proportions as this.

Immediately on the completion of this task, preparations were made for the columns. It has already been observed, in the preceding chapter, that at the foot of each column is a short columnar piece, with a flat base, called a base-plate; the fixing, and right arrangement of these plates, required the same precision of measurement as the setting out of the plan. The holes for the reception of the concrete, upon which they have been described as being placed, were now dug in the precise positions previously marked out, and the outlines of the future edifice were rendered conspicuous by heaps of gravel thrown out in regular lines over the area where the work of construction first commenced. The exact height of the bed of concrete, on which the base-plate was to be laid, was determined by pegs driven to the correct level beforehand.

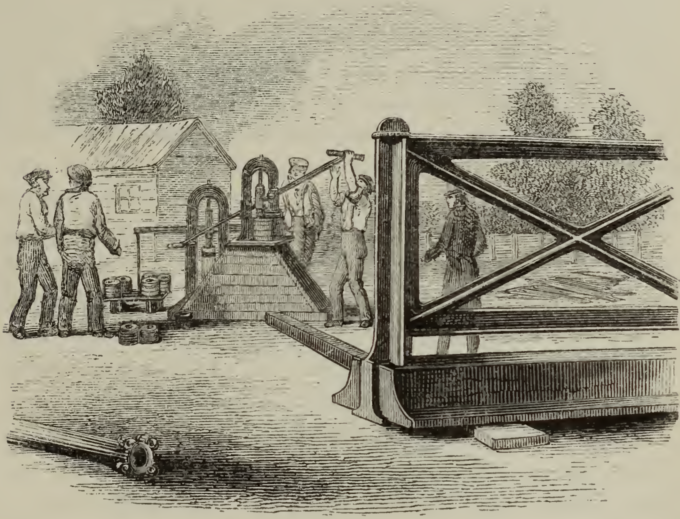
The site to be occupied by the building was so extensive, that it was scarcely to be expected that the whole would prove perfectly level; the ground, in fact, slopes from west to east, and between the two ends of the building there is an actual difference of level amounting to about 8 feet. To have reduced the whole flooring to a level plane, would consequently have demanded either the erection of steps at one end of the building, or the formation of a sloping ascent to that extremity. These alternatives were set aside by simply following the difference in the level; and by adjusting the base-plates in such a manner as to render the fall regular, from one extremity to the other, the difference of level became actually imperceptible. The columns which were placed at right angles to the floor, and not to a truly level plane, were consequently not absolutely perpendicular, but had a slight inclination to the east; this was, however, so concealed by their true perpendicularity to the flooring, that it is quite inappreciable. It can be easily conceived that the due adjustment of this trifling degree of inclination proved no small part of the early difficulties encountered and overcome in the construction of the building.

About this period, early in the month of September, iron castings began to arrive on the ground in large numbers. Heavy laden wagons were seen thronging the road from Piccadilly to Hyde Park, which were employed in carrying the as yet disunited members of this great building from the railway stations. On the ground all was bustle and animation, and the inclosed area was covered over with different portions of the structure about to be erected on it. Already the distinctive peculiarities of the building might have been surmised from the absence of all bricklayers,—bricks and mortar being replaced by iron and wood. As every casting was delivered on the ground it received a careful examination, and an immediate coat of paint.

It is a well-known fact that however carefully castings of iron are made, they are subject to slight defects which, owing to the brittle nature of the material rendering any solution of continuity hazardous, make them unfit to endure any strain, or pressure. In proportion to the size and length of the castings this danger is increased, since the disruptive force is thus spread over many, instead of few points. The cast-iron girders of this building, upon which so much of its security depended, required consequently the most careful examination of their fitness for the functions they were to fulfil. Under ordinary circumstances this might have been ascertained by simply loading them with weights to the amount necessary to prove their sustaining power. But the immense number of girders to be thus examined, rendered it absolutely essential to adopt an equally efficient but simpler and more expeditious mode.

It formed an interesting and instructive spectacle to observe the rapid and well organized plan by which this was accomplished. Immediately that the wagons from the railway, bearing the girders cast in the country, appeared on the ground, they were drawn to within reach of a large crane of peculiar form, called "Henderson's Derrick Crane." The work of unloading was commenced without delay, and the necessary tackling being attached to a girder, it was lifted by the crane out of the wagon and carried round to the ingenious apparatus contrived in order to prove its powers of resistance. This consisted of a strong cast-iron frame, at each end of which was a vertical standard. The frame being a little longer than the girder, admitted of the latter being placed lengthways and vertically upon it, the two ends being retained by a projecting piece at the top of each standard. Immediately beneath the two points dividing the girder into its three lengths of eight feet each, where, as before observed, the strain is greatest, the frame contained two strong cylinders with pistons which pressed against these points. These cylinders constituted, in fact, a Bramah's press, being connected with a force pump, from which water was impelled into them, causing the pistons to rise, and press with great power against the girder, and thus prove its sustaining capability.

It is evident that there would have been a constant risk of pushing this test too far and so injuring a sound casting, or on the other hand of not applying a sufficient test, and thereby passing over an unsound girder, had not some means of estimating the amount of force employed been added to this apparatus, which is accurately shown in the cut. In connection with the pipe leading from the force pump to the cylinder, was a sort of pressure guage constructed in the following manner. An iron cylinder with a vertical piston was connected to the pipe leading from the force pump, so that at the same moment that the pressure was transmitted to the two proving cylinders, it was also received by the cylinder in question, and consequently a proportion was established between the rise of the pistons in the proving frame and that of the piston in the pressure guage. The rise of the latter was prevented by the pressure of a lever and weights which represented the pressure to which it was required to subject the girders. The action of this apparatus was very simple. On the



PROVING APPARATUS.

working of the force pump the pressure in the proving cylinders and in the pressure gauge gradually increased and was continued until at length the piston in the latter, rising under the accumulated force, lifted up the lever and weights. As this could not take place under a pressure equivalent in the proving cylinders to 15 tons for the ordinary girders, it is evident that the proving of the latter up to that weight had been satisfactorily effected at the end of this operation.

It might be supposed that a considerable amount of time would be lost in this operation; but in reality it was carried on with great celerity, so admirable in fact were the arrangements, that it was possible for a girder to be lifted from the wagon, weighed, secured in the testing machine, proved, released, again raised and finally deposited, in less than four minutes. After the proving and weighing, the girders were set aside for use. It being desirable to ascertain the precise breaking weight of one of the ordinary girders, the apparatus was loaded up to thirty tons pressure. This immense force was sustained without apparent injury, but on applying an additional pressure of about half a ton, the girder broke. Six girders were subjected to this severe test, and all sustained pressure without injury up to thirty tons, beyond which they gave way. These experiments proved in a remarkable manner the wisdom of the plan adopted of using an open girder instead of a solid one of the same weight of metal. Other girders not intended to carry the gallery floors were only tested to a strain of nine tons. All the defective girders were of course laid aside, and in due time broken up and re-melted.

It has already been observed that a large proportion of the fittings of the different parts to each other had been effected in the foundries and workshops whence they proceeded. The base-plates, columns, and connecting pieces had all been planed or turned on their bearing surfaces, so as to admit of being accurately fitted together without further preparation, and the connexions of the girders with the columns were equally adapted to each other, without any labour of fitting, beyond placing each in its proper position. These portions required, therefore, no other attention but that necessary to deposit them securely, and in a proper manner in their already determined positions.

The fixing of the base-plates, as already described, represented for this structure the act of laying its foundations. The date of erection of the first column will be always regarded with interest. It took place on the 26th of September, 1850; and for a few hours was the only indication of that immense series which were necessary to the completion of the edifice. The manner in which this individual column was fixed was a type of almost all the more general structural proceedings in the building. In a structure required to be so rapidly completed, there would have been little time for the construction of a complicated scaffolding, leaving out of consideration the vast outlay of such a proceeding, and success depended on the absolute simplicity of every operation. Scaffolding was conse-

HYDE PARK IN OCTOBER, 1850.

quently not only entirely done away with, but the structure itself was made to subserve that purpose in the best and readiest manner. Three or four poles, lashed together with ropes, and furnished with the necessary pulleys and tackling, were all that was required, either for fixing a column, or for raising a girder. The accompanying engraving, which was taken from a photograph by the writer, represents this simple apparatus, and gives a faithful and interesting picture of the busy scene presented in the month of October. Portions of the columns and their connecting pieces are seen in the foreground; the machine in the centre is a vertical high-pressure steam-engine, driving on the right a punching and clipping engine, and on the left a drilling machine. The trees subsequently enclosed in the transept are represented as then seen with the tall columns at their side, but without the great semi-circular roof.

The simplicity of the operations of raising the columns and the girders is well illustrated in the following remarks by Mr. Wyatt upon this subject.

"In order to elevate the columns to their places, what is known in technical language as a pair of shear-legs was employed. This simple apparatus consists of two poles lashed together at their heads, and maintained in a steady position by ropes extending from the apex of the triangle formed by the base line of the ground and the inclination of the poles, to one another, to stakes driven into the ground at a considerable distance. From the apex of the triangle a series of ropes passing over pulleys were suspended perpendicularly; and, by means of this 'fall,' the majority of the columns, girders, and other heavy portions of the construction, were elevated to their places.

"Modifications of the simple apparatus described sufficed to hoist almost every part of the necessary iron-work. A connecting piece was attached to each column previous to its elevation; and so soon as two columns with their connecting pieces were fixed, a girder was run up, slipped between the projections of the connecting pieces, and secured in its place. An opposite pair of columns having been similarly elevated, another girder was attached to them; and thus two sides of a square were formed, and maintained in a vertical position by poles acting as supports to them. Two other girders being then hoisted, and slipped between the connecting pieces on the remaining two sides of the square, a perfect table was constructed. The 'shores' or supports were then removed, together with the shear-legs, and the whole apparatus was at liberty, for the purpose of recommencing a similar operation in an adjoining 24-feet bay.

"When a sufficient number of these bays had been completed, starting from the intersection of the nave and transept, to warrant the addition, the hoisting of the columns for the first floor was commenced; more lofty shear-legs being of course employed. The extension of the ground-floor structure proceeding, as that of the first floor was carried on, a base was in turn afforded for the columns of the third tier; and thus the iron frame work of the whole building rose from the ground, firm and secure, without involving the necessity of any scaffolding whatever."

An idea of the rapidity with which the columns were raised and connected together, may be learned from the fact, that in one week not fewer than three hundred and ten were fixed in their places. In fact the operation of raising and fixing a girder was the work only of a few minutes; so simple yet so secure, were its attachments to the columns. Instead of employing ladders, the workmen were run up to the point of connection of the columns and girders by tackling which supported a flat board on which the men sat in safety whilst employed in securing the girders to the connecting pieces.

From their great size and weight, the wrought-iron girders or trusses, which spanned the main avenue, giving a clear width of nearly 72 feet, required a greater amount of care, and the operation of raising them to the elevation to which they were destined, necessarily proved one of some difficulty and anxiety. It was however, conducted on precisely the same principles as that of the smaller cast-iron girders. Perhaps, indeed, in no instance is the simplicity of the constructive arrangements so extremely obvious as in this.

"The task of raising to their places the 48 and 72-feet trusses, was accomplished with great facility in the following manner:—A single mast was maintained in a vertical position by ropes, similar to those described as steadying the shear-legs used for hoisting the girders. From the summit of this mast descended other ropes, with blocks and pulleys, for the purpose of gaining power in lifting. What is called a leading or guide block, having been attached to the bottom of the mast, a rope passing through it was connected with a yoke drawn by a horse. The mast having been placed close alongside the line in which the roof-trusses had to be fixed, and one end of a rope secured to the truss, the draught of the horse caused the truss to ascend to the necessary height, being steadied in its ascent by other ropes secured to its two ends.

"When the truss thus hoisted was fixed in its resting place, the mast was moved along a plank by means of crow-bars, being maintained in a perpendicular position by the alternate slackening and tightening of the cords extending from its head to stakes driven into the ground. Having thus been moved 24 feet, it was ready for the operation of a second hoisting. Two of these great masts, fixed on each side of the transept, were used daily, and in one day as many as seven of the great 72-feet trusses have been raised to their proper position and secured, the apparatus for elevating them having travelled in a vertical position no less than 168 feet."

This operation formed one of the most animated of any in connection with the erection of the building. The tall figure of the mast with the diverging ropes employed to steady it in its position, and the remarkable task it fulfilled in sustaining the long iron trusses which were rapidly dragged up it, formed a very interesting spectacle. The girders were, with one exception, all raised in a horizontal position; in the instance named, an attempt was made to hoist the girder from one end, but the difficulty of safely accomplishing it caused the adoption of the other method as the most secure, there being a risk of injury to the rivets in the former instance. On the girder being raised to its proper height, it was secured to the connecting pieces much in the same manner as with the smaller cast-iron girders. The cut at the head of this chapter represents this operation.

At the period when this operation was performed, the amount of progress made in the works was very considerable, and an idea of the appearance to be presented by the future building, could be readily obtained by standing at one end of the, as yet, unfinished main avenues. Crowds of workmen were occupied in every direction, and the successive stages of erection, from the fixing of the base-plate, and even the digging out of the holes, to the hoisting of the girders, could be observed going on simultaneously in different parts of the wide area. The sound of hammers busily engaged in riveting the wrought-iron girders, and in other works, prevailed above every other. A large number of portable forges were in full activity, heating the iron rivets red hot, which were then immediately thrust into the holes prepared for their reception, and closed by hammering, the contraction of the metal on cooling, drawing the two portions of iron to be united into the most close and firm connexion. Horses might also have been seen dragging in different directions the columns, the girders, the base-plates, and a continuous succession of wagons being quickly unloaded and disappearing to give place to others, bringing only the same materials. The sound of high-pressure steam blowing off, and of the alternate pantings of the various engines used to drive other machines, might also be heard in various parts of the scene. Blacksmiths, sawyers, carpenters, painters, engineers, and ordinary labourers, were in full occupation everywhere, and a picture of bustling industry striving against time, could nowhere have been more aptly realized than at that period, on the once tranquil sod of Hyde Park.

The great ribs of the transept had yet to be raised, and to this part of the work of construction great importance was attached. It was felt to be the most anxious and critical undertaking remaining to be performed, all the rest being merely a question of time. It would be difficult to give a clearer and more accurate description of this proceeding than has been already done by Mr. Wyatt, from whose account we make the following extract: *

"Towards the beginning of December the climax of activity was arrived at, and the most trying operation in the whole construction of the building commenced, namely, the hoisting of the main ribs for the great transept roof. The easiest and at the same time the most secure method of proceeding, with respect to the conduct of this operation, had for some time occupied the attention of the contractors. An ingenious suggestion, made to them by one of their foremen, was at once adopted, and, with certain modifications, it was promptly carried out.

"The floor for the lead flat was already completed, so that an admirable stage was prepared upon which to make the necessary arrangements. The ends of the column into which it was designed to drop the

* Official Descriptive and Illustrated Catalogue, pp. 79, 80.

ends of the ribs, rose about four feet above the level of the lead flat, and on the tops of those columns timbers were laid, forming landing stages or tram-ways, to receive the ribs when hoisted. It was of course necessary to raise the ribs sufficiently high above the lead flat to enable their ends to descend upon the tram-ways. To effect this it was determined that two ribs should be placed on end, at a distance of 24 feet from each other, and framed together with purlins and diagonal ties, exactly as they would have to be framed in their finished state. Two complete sets of additional temporary ties were further introduced, to provide for the strain to which the ribs would necessarily be exposed from their altered position in the act of hoisting. The feet of the ribs were securely attached to stout pieces of timber, to afford the means of safely attaching the cords by which they were to be raised. Thus framed together, the ribs were moved on rollers to the centre of the square formed by the intersection of the nave and transept.

"On the extra strong trusses which have been described as spanning the nave at this point, two pairs of shear-legs were fixed at 24 feet from one another, and secured by ropes connecting them with distant portions of the building. These hoisting shears consisted of two legs on each side of the transept, each leg being formed of three stout scaffold poles lashed together at the top, and footed on planks laid across the lead flat. The heads of these shear-legs inclining slightly forwards, had connected with them blocks and pulleys from which descended ropes, attached to the four ends of the two ribs. The hoisting ropes connected with the sets of pulleys passed down from the shears to leading blocks, attached to the four columns at the angles of the intersection of the nave and transept. From these guide blocks they were poured into the area laden with iron, wood, or glass, led off diagonally to four powerful crabs, so arranged that the gangs of men employed at each were placed opposite the end of the rib acted upon by the crab they worked; and thus the foreman of each gang was enabled so to regulate the exertions of his men as to make them correspond with those of the remaining gangs, and to maintain the two ends on each side in a perfectly horizontal plane.

"As the diameter of the semicircular ribs exceeded the width of the transept by their own thickness, it became necessary, in order that they might pass between the trusses, to commence by raising two of their ends to a considerable height from the ground; and to maintain their diameter at the same angle of inclination until they were hoisted above the columns into which they had to drop. On raising them to a height of about 65 feet from the ground, the highest ends were drawn in a horizontal direction, so as to hang over a portion of the lead flats, and thus room was left to allow the other ends to be lifted to a corresponding height on the opposite side. The ribs were shifted slightly in a horizontal direction until the ends came over the columns, they were then lowered down upon rollers placed upon the tramways above mentioned, and by means of these rollers the ribs were moved along to the furthest end of the transept. The place in the centre of the building occupied by the ribs thus hoisted was immediately taken by another pair, which were similarly connected, raised, and moved to within 24 feet of the first pair.

"When the whole of the ribs were thus elevated to their places, the spaces between them were filled up with the necessary intermediate ribs and connexions; and thus the whole roof was framed together complete. The raising of the main ribs commenced on the 4th of December, and the whole sixteen were fixed in one week. It occupied about an hour to raise a pair of ribs from the ground to the level of the lead flat, but the previous preparations involved a much longer space of time. Eleven men worked at each crab, and about sixteen were employed on the lead flat, to guide the ribs in their ascent, and see to the safe condition of the shear-legs and tackle. Consider-

RAISING THE TRANSEPT-RIBS.

ing the anxious nature of this performance, it must be regarded as a most gratifying circumstance, that the whole operation was accomplished without any untoward occurrence." The cut shows the arrangements and position of the ribs in this operation.

On the successful hoisting of the first pair, an operation witnessed by his Royal Highness Prince Albert, and many other illustrious visitors, the union jack was placed on the crown of the arch, amid the cheering of the crowds of workmen below. The following description of the view from the summit of one of these arches, which appeared in a number of a daily paper, presents an interesting picture of the then state of the building:

"Viewed from the summit of these arches, the lofty elm trees beneath them sink into insignificance, while the view of the building itself is extremely grand and imposing. The roofs of the different terraces, stretching away far beneath your feet, appear like gently undulating seas of glass, and the numerous hooded glaziers' carriages, which appear slowly to navigate these crystal seas, have a peculiarly novel effect. The view of the transept and of the central aisle is remarkably fine. The vast masses of iron work which the eye is here enabled to take in at a glance, affords a more complete idea of the magnitude of the building than can probably be obtained from any other position, while, at the same time, it cannot fail to produce a feeling of astonishment at the wonderful executive powers and vast resources at the disposal of the contractors, which have enabled them, in less than three months, to achieve such stupendous results."

Having now conducted the reader through the various steps of importance in the gradual rise of this building, the glazing of the vast structure may next receive our attention. Many circumstances of an interesting nature connect themselves with this part of the structure. The immense length of the panes, the novelty of its manufacture, the extent and suddenness of its demand, all tend to place the glass of the Exhibition Building in a point of view as attractive, if not more so, as any other of its component materials. The whole of the glass required for this building was produced at the works of Messrs. Chance Brothers, at Birmingham. Its manufacture is very singular, and is entirely different to the method of producing ordinary window-glass, in which a globe of molten glass is blown out and whirled round until it flashes into a flat sheet, with the bull's eye in the centre. The quantity of glass in question required for the Exhibition Building was not less than 400 tons, and only a few months could be allowed for its manufacture. About 600 tons of sand, alkali, and other materials were required to produce this quantity, and in the heating of the furnaces not less than 3,000 tons of coals were consumed. A writer who visited the works of Messrs. Chance at the very period when their men were most actively employed in the manufacture of this glass, has detailed in the following terms the various steps of the process, from the first gathering of the molten glass to its final completion and fitness for use. "The furnace-house, to which I am now referring, is the place where the metal is produced; it is melted in large pots made of clay, and the first move towards the manufacture of a sheet of glass is by a man who is called the gatherer; he takes a hollow iron pipe, and gathers round the end, by means of a rotatory motion, at three times, such a quantity of metal as is required by the blower; for our purpose in this description we will suppose from 12 to 14 pounds weight of metal, a sufficiency to produce a piece of glass 49 inches by 31 inches in width, of the thickness required for the glass to be used in the Exhibition Building. The gatherer immediately hands his gathering to the blower in the blowing-room, where we shall follow him: in this room there are a number of furnaces and a stage composed of planks with spaces between, a couple of feet in width. When the gatherer hands the pipe to the blower the metal assumes the form of a globe; this he turns two or three times in a block of wood which has been slightly hollowed out for the purpose; he then ascends the stage, blows through the pipe which causes the globe to expand and ultimately to lengthen gradually; he next thrusts it into a furnace opposite to him, and allows the metal, which is still in a ductile state, to remain there a few seconds, when he takes it out, raises it horizontally, and swings it round by means of the stage with surprising swiftness and agility. These two processes are repeated alternately three or four times in as many minutes, the metal still remaining in the state just described, until by repeated blowings through the pipe whilst the metal is in the furnace, it gradually expands to the length named above and assumes a cylindrical form. Finally, the repeated process of blowing whilst the metal is in the furnace causes it to burst at the end farthest removed from the iron tube, and on being taken from the furnace the aperture thus produced is made level by means of a string of hot glass which is passed round it by boys, and which cuts the glass like a diamond.

"Having now perfected the hollow cylinder in the manner described, we must pass on to the flattening kiln. Here the cylinders are opened out; and the process is a very interesting one. The cylinders undergo the preparation for flattening out by being slit down by means of a diamond. In the centre of the kiln is the furnace, having the fire on the left, and at the other extreme is an aperture into which each cylinder is thrust, to prepare it for the heat required in the process of flattening. In the centre of the furnace is a flat stone, which is placed on a carriage, so that it may be moved backwards and forwards with great facility; upon the stone is a surface of glass, covered with some composition, the object of this is to prevent the glass to be flattened adhering to that which is spread over the stone; in front of the furnace stands the flattener, and with a long piece of iron he gradually draws the cylinder, which is placed in the comparative cool at his right hand on to the flattening stone: the glass again almost instantly re-assumes its ductile state; the cylinder opens, expands, and with a slight assistance from the flattener's rod, falls on to the level stone. The workman thereupon takes up a small instrument composed of charcoal or burnt wood, rubs it over the surface of the glass, and by means of a pole pushes the carriage from the furnace on to the next compartment, whence it is expertly slided off on to a cooling stone, and the carriage run back into the furnace for another operation of a similar character. In a minute or two the sheet of glass is passed on to another compartment, where by means of the flattener's rod it is raised edgeways, and gently slid into an iron box. This is the piling process, and in this position it is commonly suffered to remain, after passing the different divisions, about twelve hours, when it is removed, packed in crates, and taken to the cutting-room. One man, assisted by a boy or two, will go through the entire process of flattening out the cylinders, and complete two hundred daily."

The glazing was a very simple operation, and very rapidly performed. The sash-bars were all prepared, and the panes cut to the exact size required. There needed therefore simply that the bars should be secured in their places, and the grooves filled in with putty, to make all the preparations necessary for this part of the construction of the building. But it was a question of extreme difficulty to decide on the readiest and easiest method of reaching all parts of the roof of this immense structure now to be almost entirely covered and enclosed in glass. A large part of the glazing was effected by a simple scaffolding, consisting of a few planks placed from one girder to another, and easily accessible from below by ladders. On the stage thus formed, the materials for glazing—the sash-bars, putty, and glass, in panes—were accumulated for the use of those who were at work on that task. The manner of glazing was as follows. The sash-bar was first nailed down in the notches already cut for it in the ridge, and in the Paxton gutter, and each bar was prepared for this by having a hole drilled previously at each end, so that the mere nailing down was only the work of a moment. This being effected, the edge of the pane was inserted into the groove in the sash-bar, and a second bar was applied to the other edge and secured. The pane was then brought home by a slight push, and the grooves were filled up with putty. At the spot where the edge of the pane projected over that of the gutter, a bed of putty was laid down so as to prevent any leakage from the water rising by capillary attraction into the joint at this part, and then dripping into the building. But the scaffolding described, simple as it was, was too cumbrous for extensive use; and it became necessary to devise some more expeditious method of glazing. This was accomplished by the employment of an interesting little machine which will again come under notice, alike remarkable for its vast utility and the extreme simplicity of its construction and employment.

At one period the prospect of completing the edifice in the time agreed on was rendered extremely uncertain, in consequence of a strike among the glaziers employed. The cause of this appears to have been the novel manner in which they were required to perform their task, which seemed to militate against the established methods of proceeding, and of remuneration. On investigation the causes of complaint seem to have been ill-founded, and the work scarcely experienced a material delay. The rapidity with which a good workman could put in the panes of glass was quite extraordinary. The largest number of panes put in by any single man in one day amounted to one hundred and eight! The actual surface covered by this individual with glass amounting to 367 square feet. It will be remembered, however, that the glaziers enjoyed every possible facility for the execution of their task. The panes were already cut to the exact size, and the sash-bars, &c., all prepared for their reception. The operation was consequently reduced to its simplest features. On the completion of the glazing externally, the roof, excepting that of the transept, was covered with calico, which was securely nailed down along it.

Perhaps no subject has excited so much discussion as the painting of the Exhibition Building. Almost every kind of suggestion was made, and several were practically tried in small parts before the system adopted was fully decided on. Among several objections raised to the introduction of parti-coloured painting, perhaps the most forcible were based upon the well-known laws of colour, as dependent or influenced by latitude. In a communication which appeared in a scientific journal, it was clearly pointed out that there exists a natural law, not only as to the distribution, but also as to the intensity of colour in different regions. Birds and flowers of England are not painted as those of the tropics, and external nature assumes a more subdued character of colouring in our own than in more sunny latitudes. This fact, it was contended, should have weight in deciding on the application of colour to so large an aggregate of surface as the Exhibition Building. The parti-coloured system of painting, involving the employment of the three primary colours, blue, red, and yellow, was however persevered in and fully carried out. But the tones of the colours employed were much subdued, and a very pale blue in large proportions of surface, with a pale yellow in smaller, and a deep red for the under portions of the girders, &c., produced a harmonious combination, dependent, however, for much of its tolerance, upon the lines of white which were freely used. For the intense brilliancy of summer, when the full solar influence gives acceptance to the most brilliant colours, this system was well adapted; but in cloudy days, and days of diminished light, there can be little question that its appearance is out of character with the climate, and a more uniformly pleasing effect might have been obtained, in our opinion at least, by the employment of other colours. The division of the painting into lines of colour necessarily immensely prolonged the labour and the cost of this part of the works. The stage employed for the painting of the nave roof was very simple, and put together with extraordinary rapidity. Iron straps attached to the trusses, supported a number of scaffold poles, on which a perfect cloud of boards was laid, and as many as between four and five hundred painters by these means worked their way with great quickness from one end of the building to the other. Some idea of the magnitude of the work, and of the quantity of materials required, may be formed from the fact that not less than 70 tons of white lead were supplied from one large manufacturer, and in one day as much as 2 tons were served out from the stores.

Whilst the painting was proceeding, the fittings of the building were also set forward: beyond providing a plain deal counter, the Commissioners did not propose to proceed; all minor details of shelves and cases, were to be put up at the sole cost of the exhibitors, who were at liberty, within the space granted to them, to display their goods in any manner deemed most appropriate. Several exhibitors, in a particular class, would combine together, and thus their cases were of uniform design. In some instances the expense borne by the exhibitors, in order to produce an effective display, was almost incredibly large, when the temporary duration of the Exhibition was considered. Perhaps no cases were so distinguished for their elegance, simplicity, and good taste, as some of those erected by a number of Parisian exhibitors, and of the silk manufacturers of Lyons; many of these were, however, not fit for public inspection for at least a month after the opening. In the completion of the fittings of exhibitors, the most marvellous celerity was used towards the last; and the short interval that elapsed between the Monday and the Thursday of the opening, witnessed the most unexampled spectacle of industry ever presented. In these three days confusion gave place to order, and a scene of irregular and tumultuous bustle to one of regularity and comparative quiet.

We have thus attempted to convey a succinct but accurate account of the progress of this vast enterprise, from its earliest period to its completion. The gradually increasing intensity of the work, is learned, in an interesting manner, from the increasing numbers of workmen employed :—

1850.	In the week ending	Sept. 6,	39	men were employed.
	,,	Oct. 4,	419	,,
	,,	Nov. 1,	1,476	,,
	,,	Dec. 6,	2,260	,,
1851	,,	Jan. 3,	2,112	,,

and from that time, until within a month of the opening of the Exhibition, the average number rarely fell below two thousand.

It may be readily imagined that only by the most thoroughly organized system of business, coupled with experience in the management of a large number of operatives, could this enormous number of persons have been employed, with satisfaction to themselves and to their employers. The mere calculation of wages, and the mechanical act of paying them, were attended with many difficulties. It may be interesting to learn the method adopted for this purpose; and the following extract, from an illustrated paper, relating to the Exhibition, conveys a very good idea of it:—

We will suppose that T. B— (sleeper-layer), J. S—, and J. J—, make application at the Industrial Palace for employment. T. B—, is engaged at *3s.* per day, the others according to their department of labour, and all are requested to come to work on the following morning (say six o'clock); at the time of this agreement, each man receives three brass tickets; on that given to T. B—, No. 1921 is stamped; on J. S—'s, 1922; and on J. J—'s, 1951. *The names and numbers of the men are now entered in the gatekeeper's book.* The first of the three tickets is of an octagonal shape, and only has the number of the workman and name of the firm, Fox, Henderson, and Co.; the second is oval, and has, in addition to the above, the word *Breakfast;* the third is circular, and has *Dinner* stamped upon it.

We will suppose that B— and his comrades arrive punctually at the building at six o'clock in the morning, and each deposit the ticket No. 1 in a box prepared for the purpose. As soon as the men have all passed into the works, a number of boys begin to sort the tickets. Such numbers as come to hand are entered in the *gatekeeper's book;* for instance, if his first week's work commences on a Saturday, T. B—'s time is entered thus:—

No.	Name.	Occupation.	S.	M.	T.	W.	Th.	Fr.
1921	T. B.	Sleeper-layer	6					

It will be seen that the figure 6, placed to B—'s credit in the gatekeeper's book, is put to mark the proper commencement of his day's work, and, if allowed to remain without addition, shows that a whole day's work has been done; but, if it should happen that anything should prevent him from coming after breakfast, his account would be placed thus:—

No.	Name.	Occupation	S.
1921	T. B.	Sleeper-layer.	6-8

The addition of the 8 after the 6 would show that he had only worked from 6 till 8 o'clock. The gatekeeper's book is an important part of the means by which the settlement with the workmen is effected; but, as a check to this, the superintendent of each class of workmen is at his post before the bell rings, and sees that every man takes his proper place; each superintendent also keeps a book.

On Friday night the pay-list is made out thus:

EXHIBITION PAY-LIST.

No.		Time.		Rate.		Total.		
		d.	*h.*	*s.*	*d.*	£	*s.*	*d.*
1921	T. B.	4	7½	3	0	0	14	3
1922	J. S.	6	0	3	6	1	1	0
****	* * * * * *							
****	* * * * * *							
****	* * * * * *							
1952	J. J.	5	0	3	0	0	15	0
This list contains 30 names, and the amount of the whole comes to .... £						43	17	0

To make up this sum (43*l.* 17*s.*) requires—

£	*s.*	*d.*	
29	0	0	Sovereigns.
9	10	0	Half-sovereigns.
5	7	0	Silver.
£43	17	0	

The pay-list being completed, and the necessary quantity of various kinds of money brought into the bank to meet the week's expenses, trays are then filled with small zinc boxes, in each of which is a piece of paper with the number, name, and amount of work done by each person employed, placed in it (see Table p. 83). On the paper is inscribed:—

1921,
T. B—,
14*s.* 3*d.*

The condensed pay-list placed in the bank, consists of many pages; and the total amount having been calculated, and the money arranged, we will suppose that all the zinc boxes have been properly filled, until we come to 1921 | T. B—, | .

This commences a page of the pay-list. The party engaged in filling the cases, calls for more money. "What number do you begin with, sir?" asks the party who has charge of it. The reply is, "No. 1921." "And you finish with 1952?" "Right," says the other. On which 29 sovereigns, 19 half sovereigns, and 5*l.* 7*s.* in silver are handed over. If this money supplies the sum required to fill each zinc case, and neither a sixpence is left too much or deficient, the balance of that page is signed by the party who works that particular number. If, in the same way, the whole of the two thousand zinc cases are filled, and there is neither deficiency nor surplus, it is scarcely possible that any mistake can be made in the sum due for wages to all the workmen. The whole of the boxes, from No. 1 to No. 2000, having received their proper complement of money, at half-past four o'clock on Saturday night the bell rings. From all directions hundreds of men are seen advancing in continuous streams towards the bank; the ladders leading from the roof and other parts of the building are crowded with hastening multitudes. As party after party reach their post, loud voices, and at times cheering, are heard: this, however, soon subsides. To prevent crushing or confusion, stations are appointed for the men according to their numbers; for instance, against one column is placed a board on which is painted 1 to 200; on another, 200 to 400; in a short time all are placed in their proper position; and No. 1 then proceeds to the office window, and being asked his name and number by a person appointed, having answered, he receives the zinc box marked No. 1, and, having emptied the contents, he casts the empty box into a basket a few feet from the pay-hole. No. 2 and so on follow in quick succession; in fact, the rapidity of the stream, or, we may say, flood of workmen may be judged of by the fact to which we have already referred, that the whole are paid and have left the works in about half an hour from the commencement of pay-time.

It is very satisfactory to learn that notwithstanding the absence of all scaffolding, and the apparently perilous occupation of the workmen employed in the erection of the building, comparatively few accidents occurred, and these, with a few exceptions, were not of a fatal character: it is, in fact, scarcely conceivable that where two thousand operatives are constantly employed among heavy machinery, and in the performance of such duties as repairing the roof, accidents should not occur. In one instance, which excited some public attention, a carpenter was killed in consequence of the breaking of a small cast-iron shoe, upholding one of the gutters, and on which, although directed to the contrary, the unfortunate man placed the scaffolding, which gave way under his weight.

The erection of the boiler-house, which contained the steam-boilers for supplying the various steam-engines in motion in the building, will come under notice on another occasion. We have, in the present chapter, occupied ourselves simply with tracing out the progress of the great Exhibition Building in its constructive details, from the erection of the first column to the completion of its fittings and decorations. The construction of such a building, in the time occupied, about four months, is without historical parallel. Three hundred years were required to complete the building of St. Peter's, at Rome ; the erection of St. Paul's, in London, occupied thirty years ; and though it be true that the solidity and permanence of these structures justify the period occupied, yet, in the present instance, the principal materials are scarcely less durable, nor do they necessarily demand more constant repairs than those employed in the former buildings. That which has been accomplished could never have been done in any other country in the world, and while we may feel an honest pride in the energy and skill of our people and times, it were rash, ungrateful and dangerous to forget the Author and Giver of all, whose favours of providence and grace have so long been scattered with unsparing bounty upon this kingdom.

CHAPTER VI.

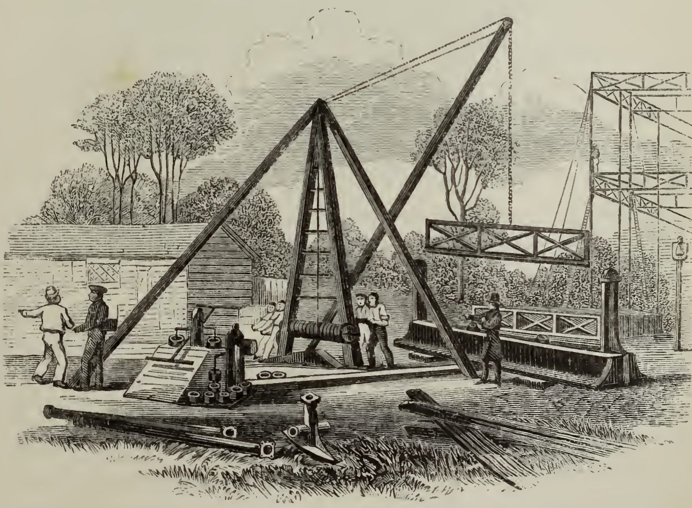
MACHINERY EMPLOYED IN CONSTRUCTING THE EXHIBITION BUILDING.

It may be safely averred that only in an age of advanced mechanical application could the Exhibition Building have been erected. It is impossible to conceive of the enormous quantities of elaborated materials employed in its construction being prepared within a reasonable period by any but mechanical means. When gutters and sash-bars had to be made by the mile, and girders and columns cast by the hundred, it is obvious that human labour, even on the most extensive scale, was inadequate to the task, that is to say in the short interval of four months. The only portion of the building—and it is a very large portion, if regard be had to the number of superficial feet covered—to which human labour, as distinguished from that of machines, has largely contributed, has been in the manufacture of the glass. But it will be at once perceived, that this department of labour, in which large results are easily attainable in a short space of time, an extensive surface of glass being produced at every operation of the blower, does not admit of a just comparison with that occupied in the production of a gutter or a sash-bar, either of which if made by hand would have consumed a very considerable amount of time, although but a small result would remain in evidence of the labour bestowed on it. And it is deserving of remark that the glass itself was indebted to an ingenious glass-slitting machine, for its regularity of size, and evenness of edge. It may be almost superfluous to remark that the casting and fitting of the girders was chiefly accomplished by the assistance of machinery, guided by manual labour.

The first machine to which our attention may be directed as co-operative with the labourer in the construction of the building, is the Derrick-crane, patented by one of the partners in the engineering firm, who were contractors for the structure. The name "derrick" is derived from the movable beam fixed to the foot of the stem, and forming the point of suspension for the load. The derrick-crane consists of an upright stem, the derrick, and the stays; these are usually made of timber.

The upright stem consists of two pieces of timber, which meet at the top, and are connected both at top and bottom by means of cast-iron shoes. The lower shoe is constructed so as to turn on a fixed pivot; and the upper shoe is also fitted with a pivot, by which it is connected with the pair of stays, and which enables it to be turned freely round. The crab-engine, or lifting apparatus, is worked by three men, and is fixed at the bottom part of the stem, the roller, or chain-barrel, being fixed between the two parts of which it is composed. The stays are fixed at their lower ends by being attached to horizontal sleepers, which meet at the centre of the crane, and support the lower pivot of the stem.

The derrick, which is constructed of a single piece of timber, has a cast-iron shoe at the top, and another at the bottom, the lower end being jointed by a pin to the bottom shoe of the stem, so as to enable it to be moved vertically. Winch-handles, with wheels for single and double purchase, together with the barrel, form one part of the lifting apparatus; while the other part, which raises or lowers the derrick, consists of a barrel and two wheels, by which it is connected with the first portion of the lifting mechanism by means of a clutch fixed on the spindle of the lift barrel. The derrick is supported by a chain, passing from its barrel and up the stem to a pulley at the top. From this pulley it is carried nearly to the top of the derrick, to which it is fixed. Another chain passes up the back of the derrick, from its barrel, to a pulley at top, and thence down to the load. In order to prevent the derrick barrel from turning, the two portions of the lift-apparatus are disconnected—the derrick being supported by a catch, or pall, which acts on one of the coupling-wheels. When the two parts of the lift-apparatus are disconnected, the crane is in a proper state to be used in raising its load; and when it is necessary to move the load nearer to the centre of the crane, the two barrels are again connected, simply by means of the clutch, the motion of the lift-apparatus being reversed. When the load has to be moved nearer to the centre of the crane, it is necessary to raise the derrick.

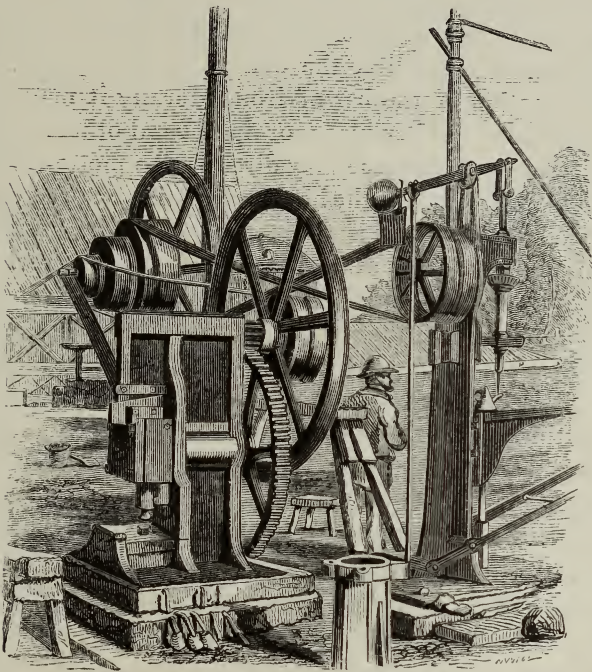


THE DERRICK CRANE.

This power of elevating or depressing the movable beam or derrick, which supports the object to be moved, confers considerable advantages on the machine, and enables it to deposit or to lift objects, at any desired point, near or distant from the stem, in proportion to the length of the derrick, which could not be so readily effected by the instrumentality of ordinary cranes. The machine was extensively employed in the erection of the building. It was used, as shown in the cut, to unload the girders from the wagons in which they were conveyed, and to carry them to and from the proving-apparatus, and also in placing the heavy machinery of the machine courts in their position in the building; and in short in every operation in which a crane was required, not only in the construction, but also in the reception and discharge of goods from the building.

The machines to which we shall next refer, are those employed for the purpose of drilling, and for punching and clipping. These machines are both represented in the accompanying engraving, from a photograph taken whilst they were in use for the erection of the building. Both machines are very simple in their arrangements and operations, but represent a highly important and necessary adjunct of all great engineering proceedings, in which cast and wrought iron are materials requiring to be adjusted and adapted to position. The drilling-machine might be employed for making holes either in cast or in wrought iron; but the punching-machine could only be used for wrought iron, as if employed on cast iron, the metal would be split in pieces. The drilling-machine was consequently in very frequent use for all purposes, although it required a longer time to bore a hole by its means than by that of the more powerful punching engine.

The drilling-machine consists of a strong upright stand of cast iron. On one side of this stand is the drilling apparatus, and on the other the pulleys which set it in motion. The bar of iron to be drilled is laid upon a flat bed of cast iron, capable of moving up and down the stem of the machine, by means of



PUNCHING AND DRILLING MACHINES.

a rack and pinion. Immediately above it is the vertical drill which is set in rapid rotation by a pair of bevel cog-wheels, one on the drill, and the other on the horizontal shaft, at the opposite end of which are the fast and loose pulleys, over which the driving band runs. The drill is capable of being depressed so as to bring the borer down upon the iron to be perforated. This is effected by a treddle, which acting on a lever enables the workman by pressure with his foot, to cause the borer to act on the iron, and cut its way entirely through its substance. This operation is attended with the development of so much heat, that the water and soft soap, which form the lubricating mixture for facilitating the action of the drill, are actually set boiling, and steam rises from the heated metals. When the hole is drilled, the workman's foot is released from the treddle, and the balance weight at the top lifts the drill out of the hole: by a little motion of the bar of iron laterally it may now be drilled in another place, or in several others as the requirements of the case may direct. The motion of the drill received through the horizontal axis from the driving band and pulleys is derived from a high-pressure steam-engine, or any other source of motive power.

The punching and clipping-machine is an ingenious though simple engine, by which two operations, each requiring enormous force, are performed. It is capable, either of punching holes through solid iron, or of cutting iron in the same manner as a scissors cuts paper. The punch is at the lower, the shears or cutting part at the upper portion of a cast iron frame of great solidity and strength. At the back of this frame is a large cogged wheel, driven by a small pinion on the axis of which are placed the fast and loose pulleys, and the fly-wheel—the latter being rendered necessary in this instance, in order to convert the variable force arising from the movement of the punch into a constant motion; without this addition the machine would run very quickly in the interval between each descent of the punch, and would scarcely move when the resistance of the punch against the iron was rendered sensible. The axis of the larger cogged-wheel entered the cast-iron body of the machine, and by an internal arrangement its rotatory motion was converted into an up-and-down movement, affecting the punch and the shears. The iron bar to be perforated was placed on a bed of cast-iron, with a hole in the middle, so as to give passage to the punch after it had penetrated the iron. The punch consisted of a solid round plunger of steel, and was driven slowly, but apparently with the greatest ease through the yielding substance of the iron below. In the same manner when it was necessary to clip the iron, the great shears alone, by the upward movement of its lower blade, effected it easily. In this instance the heat developed was much greater than in the former, and the small circular piece punched out was so extremely hot, as to burn the fingers if incautiously touched. The caloric,—to use a favourite expression of some physical philosophers, appeared to be literally *squeezed* out from the metal. The term punching-machine does not convey a just conception of the action of this apparatus. In order to gain the requisite power, its motion is extremely slow, and not at all impulsive, the descent of the plunger being measured and gradual, as though one thrust a finger into yielding dough, and the hole was made apparently without an effort. Perhaps a period of two seconds was occupied on the average in its passage through the metal. It has been stated that three thousand holes could be punched in an ordinary working day by one of these machines. Both the punching and the drilling-machine were chiefly employed in making holes in the iron bars for the reception of rivets, for the wrought-iron trusses which spanned the main avenue. Both machines were driven by a vertical high-pressure engine of four horse power, so arranged with boiler, chimney, &c., as to be quite portable, and capable of being conveyed with the machines to any part of the busy scene where its services were most required. The exhibition contained several beautiful specimens of these important though simple arrangements of machinery for punching and drilling, &c., and to some of these it may be on another occasion our duty to advert.

One of the machines to which public attention was earliest directed was that invented by Mr. Paxton, for cutting out the sash-bars. It is to him that the original idea of cutting those portions of the roof out by machinery is due, and this idea gave birth to other important adaptations and improvements in the application of machinery to what is called usually, carpenter's work. It is only of late years, that machinery of an automatic or self-acting character has been applied to the working of wood. The simple operation of sawing has been effected by machinery for many years, and by the circular and vertical saw, timber in the rough is prepared for the shaping out, which has generally been committed to the carpenter. At our dockyards, it is true, that a beautiful and ingenious machine has been in extensive use for cutting out the blocks for pulleys, the wood being received almost in the rough, and a finished block being turned out by the machine. But to ordinary purposes of construction, such as the manufacture of window-frames or bars, machinery has not, until of late, been made applicable. The machine employed by Mr. Paxton for cutting out the sash-bars of the great conservatory at Chatsworth, was very simple in principle. It consisted essentially of a saw, the teeth of which were arranged so as to cut out the exact pattern of the bar, when a straight piece of wood was submitted to it. This machine did not appear to present the highest advantages when proposed on a large scale; and a modification of it was consequently adopted.

The whole of the sash-bars were made by the inventor of a modified engine of this description, at some saw-mills near Regent's Park. When it is remembered that in the space of three months, no less than 200 miles of sash-bars had to be made and finished, it may be conceived that extraordinary mechanical facilities were necessary to secure such a result. The machine acted in the following manner: a plain plank of wood was placed in it at one end, and was immediately seized by a pair of rollers, which presented it to an axis armed with cutters, and revolving at a very rapid rate. The cutters were so arranged as to cut out the outline of the bar in their revolutions. After this the plank was drawn forward to an arrangement of circular saws, which cut out the grooves for the glass, and also cut the plank through into the requisite number of bars for which it was intended. The sash-bars were thus completed in most respects, although not entirely so. One machine was found capable of operating on three hundred planks a day—that is, in ten hours, the length of sash-bar thus completed being nearly 3 miles daily.

The sash-bars required to be cut all to one length in order to avoid the necessity of performing any carpentering operations on the roof in fitting them into their places. This was effected at the building. A beautiful portable steam-engine with two cylinders was employed to give motion to several of the machines in use there, for these and other finishing operations. The machine for cutting them all into equal lengths was very simple, and operated on thirty sash-bars at once. It consisted of a movable frame to receive and hold fast the sash-bars, while on either side a circular saw, set at the required angle, cut off the projecting ends to the necessary distance, leaving the bars each of precisely the same dimensions. The ends of the bars were also cut at the same time into a notch, fitted so as to be made secure in that of the gutters. The sash-bars were now of the required size, length, and shape; but in order to make their preparation for fixing quite complete, it was found necessary to drill the holes by which they were to be fastened to the ridges and edges of the gutters.

The sash-bar drilling-machine was a very simple one, and thus differed much from that employed to cut them out of a solid plank; but it was an engine which, from the fact of four or five boys being always employed at it, gave it some degree of interest to the spectator.

On a horizontal bench, placed at right angles to the main pulley-shaft, are placed in front a series of driving pulleys, with as many horizontal drills turning in proper brass bearings: these pulleys are made to rotate by means of a leather strap, or band, from a pulley on the main pulley-shaft. The use of these drills is to make the nail-holes at either end of the bars. Four boys and one man were engaged at this branch of the operations; the man superintended the whole, and kept the machinery in order; while the boys each attended to one drill. There are additional drills on this and another bench, if required by a great press of work. Opposite to each of the boys is a wooden traversing plate, working in the direction of its corresponding drill: the lower end of the bar, resting on this traversing plate, is pushed forward with it against the drill, until the requisite perforation is entirely completed. While one end of the bar is being bored, the other end rests in an inclined position against a wooden rail placed longitudinally above the pulleys, having as many sinkings thereon as there are drills. The wooden rail, to which it is secured by a fillet, projects from an inclined frame of the same material firmly secured to the bench. At the outer end of one of the driving pulleys is a *cutting-cup*, by which the ends of the wooden dowels, or keys, 3 inches in length, are rounded off, merely by being held therein by a workman or boy during the revolutions of the pulley.

Even the painting of these bars was effected by machinery. It is well known to practical men, that the time occupied in painting sash-bars by hand is a very serious item of expense, simple though the operation really is. To paint 200 miles of sash-bar thrice over, or in all 600 miles appeared a most formidable affair, and an attempt was made to use a machine for this purpose. A short explanation will render the simple apparatus perfectly intelligible. It consisted of a long trough filled with fluid paint, and sufficiently large to allow several bars to float in it. Several bars were always in it at one time, so as to ensure their surface being thoroughly covered with paint. At one end of this trough was an arrangement of brushes, through which a sash-bar on being lifted out of the trough was pushed, and on reaching to the other side, was drawn out with the paint as evenly and smoothly laid on it as though it had been done by the workman. In order to catch the dripping paint falling from the bar whilst being drawn through the brushes, a small wooden channel was provided which conveyed it into a can, and so obviated all waste.

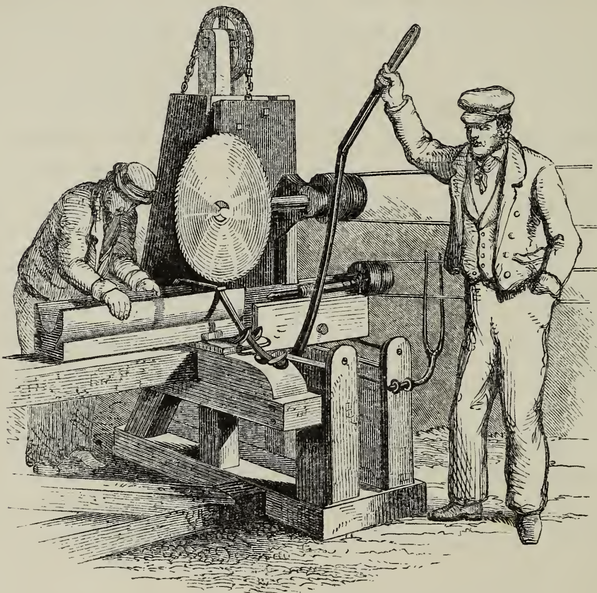
The Paxton gutters, the form of which was much more complicated than that of the sash-bars, were, as it has been repeatedly mentioned, cut out by machinery. And in this instance, as in the former, the interesting spectacle might have been seen of a plain piece of timber entering the machine at one end, and emerging from it in a finished form at the other. In essential principle, this machine is similar to the other for cutting out bars and ridges; but in arrangement it is of course very different. It must be borne in mind, that, besides the rain-water gutter in the top of the timber, there are two inclined gutters cut in the sides of the gutter timber, the purpose of which, is for receiving and carrying off the condensed vapour from the inside of the glass of the skylights. When finished the gutter is 5 inches in width, and 6 inches in depth: the top or rain-water gutter being 3 inches wide, and 2½ deep; and the "condensation gutters" each 1 inch deep, and half an inch in width. The whole operation of giving it this form is performed by this very ingenious piece of machinery.

Motion is given to the gutter-cutting machine by means of two pulleys. The timber to be operated on is first planed to the proper size, and then presented to the feed-rollers, which draw it forward; and it is then subjected to the roughing cutters, which take out a depth from the top of the gutter-timber of 1½ inch. The roughing-cutters are caused to revolve by means of a driving-pulley on the same axle, which pulley is driven by a band passing round the pulley on the main shaft. The circular body or stock of the roughing-cutters is of solid cast-iron, 12 inches in diameter, from which the cutters project. These cutters are four in number, and 9 inches apart from edge to edge.

The timber after leaving the roughing cutters is still drawn forwards, and becomes amenable to the action of the finishing cutters.

The three finishing cutters, which are, of course, placed in advance of the roughing cutters, are set in motion by as many bands passing round three respective driving-pulleys each of 9 inches diameter. The finishing cutter furthest from the engine finishes the rain-water gutters, while the other two give the entire form to the inclined condensation gutters. Eighty-four lengths of solid gutters were passed through and finished, as regards their transverse section, in twenty hours: thus a total length of 2037 feet was ready to be carted off to the building in Hyde Park each day.

The amount of labour performed by this machine has been calculated to be equal to that of 300 men, or in other words, if the machine and 300 carpenters were at work simultaneously, the former would turn out as much work as the latter in the same period of time. When the gutters were delivered in Hyde Park, they required to be finished at the ends, and this was effected with the ease and rapidity which characterized all the constructive operations. It has been already stated that the gutters were supported below by wrought-iron rods, passing through cast-iron supports, which were tightened so as to give a slight degree of curvature to the gutters, and thus facilitate the discharge of the water from it. In cutting the ends of the gutters, it became consequently necessary to give them this form in order that the cut surfaces might accurately adapt themselves to each other when placed in their position. A little reflection will render it evident, that had the ends of the gutters been cut when they were quite straight, they would be thrown out when bent by the tightening of the rods. It was necessary, also, to make the holes in them for the discharge of the water into the proper channels for its reception. The mechanical arrangements for effecting these objects were worked on the ground in Hyde Park, in juxta-position with the other finishing machines, and driven by the same engine. This machine is shown in the cut. It has been described as follows. A large circular saw, the spindle of which could be raised or depressed by the action of a lever, had fixed in the centre of one of its sides two gouges, adapted to produce, by rapid revolution, a semicircular groove. A frame, the exact length of the gutters, was fixed at right angles to the plane of this saw. In the centre of this frame a species of chair was constructed, capable of turning round, and a shoe was fixed at the extremity of the frame farthest from the saw. The end of a gutter about 24 feet long was thrust into this shoe, and its middle supported by the chair already mentioned. The end nearest to the saw was then pressed down, and secured by an iron strap. Thus retained in position, it was necessarily bent to precisely that form arranged to be ultimately given to it by suspension-rods and struts. The circular saw, revolving rapidly, was then made to descend until its edge came in contact with the end of the gutter, which



CIRCULAR SAW FOR THE GUTTERS.

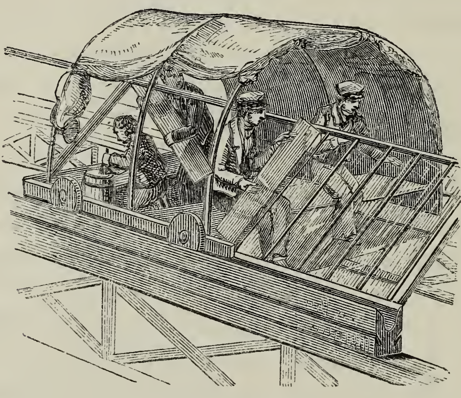
it cut to the precise length required, and at exactly the right angle. The axis of the circular saw was then still further lowered down, until the gouges fixed on its side cut their way through the gutter, making a semicircular groove through its depth. One end being thus scooped out, the gutter was released from its position, turned round, and secured in a contrary direction in the shoe at the opposite extremity of the supporting frame. The other end of the gutter, thus presented in its turn to the saw, was then subjected to a similar process, after which it was removed, perfectly ready for the attachment of its iron bowstring.

The glazing of a great part of the building was effected by assistance of simple and ingenious machines which were made to traverse the roof. The glazing of the transept was a work of some difficulty, in consequence of the curve of the arched roof; it has been thus described by Mr. Wyatt.

"No sooner had the skeleton of the transept-roof been completed, than the work of glazing commenced. For a considerable portion of the height of the curve, ladders and temporary scaffolds enabled the workmen to proceed with their labours; but in order to complete the upper part an ingenious box was constructed, moving on wheels in the line of the gutters. This box was lowered down from the lead-flat at the summit to any portion of the roof.

"The glazing of the nave roof presented formidable difficulties, from the great extent of work to be got through in so short a space of time. The ingenuity of the contractors was, however, brought to bear upon the subject, and provisions were made by them for the simultaneous glazing of large areas, entirely independent of variations of weather. Seventy-six machines were constructed, each capable of accommodating two glaziers; these machines consisted of a stage of deal about 8 feet square, with an opening in its centre sufficiently large to admit of boxes of glass, and supplies of sash-bars, putty, &c., being hoisted through it. The stage rested on four small wheels, travelling in the Paxton gutters, and spanned a width consisting of one ridge and two sloping sides. In bad weather the workmen were covered by an awning of canvas, stretched over hoops for their protection.

"In working, the men sat at the end of the platform next to whatever work had been last done; from which they pushed the stage backward sufficiently far to allow them to insert a pane of glass, and as soon as that was completed they moved again far enough to allow of the insertion of another. In this manner each stage travelled uninterruptedly from the transept to the east and west ends of the building. The dexterity acquired by the men in working the machines was very remarkable. By means of them eighty men in



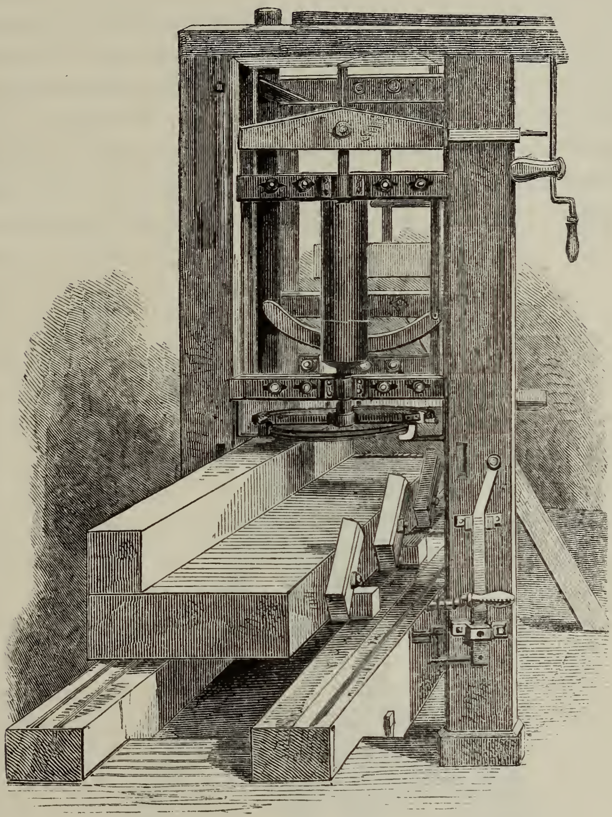
GLAZING WAGON.

one week put in upwards of eighteen thousand panes of glass, being not less than 62,600 feet superficial. A somewhat similar machine has been constructed for the purpose of effecting any repairs that may be necessary in the finished roof, with the difference that its wheels travel upon the ridges instead of in the gutters, and that of course there is no aperture for the purpose of hoisting." The cut represents this machine.

Machinery has been now seen to have been applied to the production of a large part of the actual elements of construction of this building. The sash-bars, ridges, and gutters forming the principal portion of the roof, were all cut out by machinery, and the two former painted also by mechanical means. It is interesting to notice that for a portion of the building so apparently unimportant as the handrail of the staircases and galleries, machinery was likewise used. In fact the vast quantities of every part required, rendered it indispensable that a rapid and ready method of preparation should be employed. The hand-rail-making machine was a very simple apparatus. The wood used was mahogany, which was first cut by circular saws into square pieces, and the angles were afterwards taken off by the same means. In this state the wood was supplied to the machine. A piece of timber was placed in the bed of the machine, and gradually drawn forwards by a handle; in its progress it was presented to a hollow cast-iron cylinder revolving with immense velocity, and furnished on one face with four cutters. On the wood touching these cutters, it was immediately reduced to a smooth circular form, and the hand-rail was passed entirely through the cylinder, emerging from it as a smooth round rod. So perfectly did the machine fulfil its duties, that the rails merely required a little sand-papering and French polishing to complete them. The length of the rails was 24 feet, and the machine completed about thirty such lengths as its day's work.

In the preparation of the timber for other uses, machinery was also employed, and manual labour was reduced to its lowest degree of requirement. It was necessary to have the planks employed for the flooring and other parts of the building all of one thickness; and as it was impossible to do this within the time by the ordinary processes of adzing and planing by hand, a machine was used. The part of this machine representing the carpenter's adze, consisted of a cast-iron stock, with two cutters secured to it. The machine also planed the wood, and this was effected by three planes, so set as to act on the under surface of the plank, while the revolving cutters, or "adze" acted on its upper surface. The apparatus consisted of a strong wooden frame, about 23 feet long, at a convenient height from the floor. At one end of it were arranged the planes, and at the other the revolving adze; and between these was a pair of circular saws. The requisite motion to the cutters, saws, &c., was given by bands led off from the driving shaft, and the cutters and planes were kept to their work, or in other words, the plank was pressed sufficiently close to them, by means of pressure-rollers. The process was as follows: —the plank was placed by an attendant on the bed of the machine, and was connected to a chain which slowly dragged it forward. It was first presented to the edge of the three planes, which cleanly removed a certain amount of the thickness by reducing its under surface. In order then to ensure every plank being of similar breadth, it was drawn forward between two circular saws in rapid revolution, which cut down its sides whenever they exceeded a certain standard of breadth. From these it passed onward to the cutters, which removed the unevenness from its upper surface. The plank was then finished, and was succeeded without interruption by others, so as to reduce the whole to a continuous process. The action of the machine was extremely interesting, as it emitted flakes of wood at one extremity, and a shower of pieces hewn out by the adzes at the other.

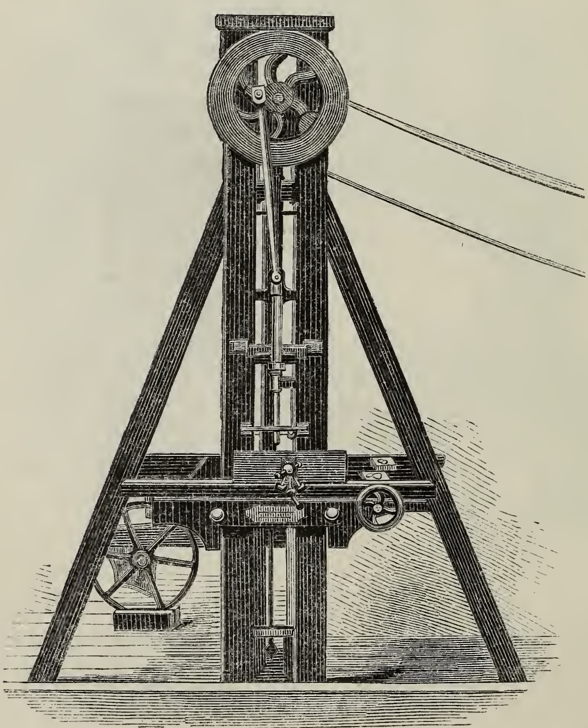
Another planing-machine of a more simple construction, was also employed for general purposes. This was afterwards exhibited in motion in the building. The annexed engraving represents this engine. This machine was used in preparing the timber for the Paxton gutters. It consisted of a strong frame placed horizontally, on which the wood to be planed was laid, and a vertical framework which gave support and attachment to the cutting mechanism. The cutters were attached to the ends of an arm revolving with great velocity, and they were adjusted so as to act on the upper surface of the timber, and remove a certain thickness from it. In order to keep the timber steady, it was firmly secured in the horizontal frame; but this was also made to move slowly forward, so as constantly to present a fresh surface to the action of the planes until the whole length of the timbers had been operated upon. Three widths of timber were planed at one time; only one, however, is shown in the cut. The re-



PLANING-MACHINE.

volving motion of the cutters was communicated by a pulley and band alone. There was also a round disc of cast-iron made to press upon the timbers, so as to keep them tight down in the traversing frame. This machine was patented.

The mortising-machine exhibited in the annexed engraving, was also employed in expediting the work, and with the other was shown in operation in the Exhibition. The term mortise is applied to an excavation in timber, made to receive a projecting piece in another timber, so as to hold both together. It may be well imagined that in the construction of the roof of the building many thousands of such excavations would be necessary, and to have effected these by the ordinary means would have involved immense loss of time. The machine was consequently employed for this purpose. Its action is very simple and easily understood. The timber to be cut is placed on a rest, above which the



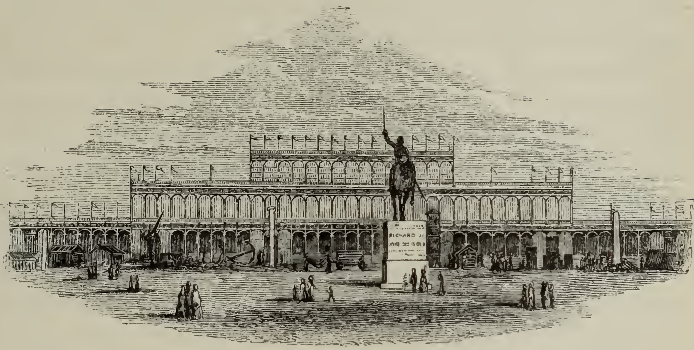
MORTISING-MACHINES.

cutting tool is placed. The chisel is fixed to a vertical rod, which is supported in front of the upright frame of the machine. This rod can be lowered by pressing on a treddle in front. By this action the chisel is driven forcibly down, and of course cuts the timber beneath it. A spring is so arranged as to lift it up after having made the cut, and thus by the mere action of the foot the operation of mortising can be carried on, leaving the hands free to direct the chisel in its action on the wood. The utility of this very simple machine was such that one man could get through seven or eight times the amount of work he could otherwise have effected. The direction of the chisel could be altered so as to cut in any required way.

In addition to these machines, most of which were entirely new, and appear to open a new field of mechanical application in the art of construction, were several benches to which circular saws were fitted. These were driven by the small and powerful high-pressure engines placed in different parts of the Building, and though little interesting in themselves, always attracted much attention by the rapidity of their action, and the peculiar ringing sound produced by them in cutting up timber. These saws were of extensive utility in a number of the minor operations of the works, and several were almost constantly in work.

We have now passed in review every mechanical arrangement adopted in the construction of the Exhibition building. Some of these were of a very complicated kind, and almost approach in merit the beautiful automatic arrangements in use in our factories, while others were extremely simple, and are to be regarded merely as instances of a happy facility of adaptation. But the whole strongly indicates the fact that the disposition of the English mind is in gross results in every possible instance to rely upon machinery, rather than upon the trained efforts of the workman. The necessity for mechanical proficiency in the workman in the production of such a simple thing as a sash-bar, is consequently entirely obviated, and his labour is free to be bestowed upon those departments of construction in which no mechanism can supersede his efforts. After what has been done in the instance of the Exhibition building, there can be little question that in all similar works in future, similar means for superseding manual labour will be adopted. But in the ordinary works of every-day life, the workman will still have to pursue the path trodden for ages before.

CHAPTER VII.



GENERAL ARRANGEMENTS OF THE BUILDING.*

THE best conception of the magnitude of the Exhibition Building was not to be obtained by any view of it taken on the general level of the surrounding surface. Not more than one or two spots could be selected which gave even an idea of its entire length, and from none could it be seen without the interruption of groups of trees, which broke the perspective, and interfered with a correct appreciation of the real length of the structure. From every other point of view, on the ground level only, small portions of it were visible, and these failed to give a just impression of its proportions. Perhaps, the best view of this kind was attainable from the bridge in Kensington Gardens, or near that spot. From thence the furrowed outline of the glittering roof of the transept appeared in bold relief against the sky, and the northern façade

* The cut represents the western entrance of the Exhibition building.

of this portion of the building, with the great fan-light of the transept, formed a very striking feature. The eastern and western extremities were also partly visible, and the vast extent of the structure became, in some degree, capable of admeasurement by the eye; but it was only from the length of the transept roof, at this point distinctly visible, that an idea could be at the same time formed of the breadth of ground over-shadowed by the building.

From the summit of some of the tall residences in the vicinity of Hyde Park, the most complete view of the building was to be had; and from no point better than the tower of the large floor-cloth works in this neighbourhood. From this point the whole structure was visible. A wonderful spectacle in truth it formed! The immense length and breadth were here appreciable, and the terrace-like form of the structure was shown in a remarkable manner. The relation of the transept to the building was also beautifully exhibited here, and its glassy arch glittered in the sun. The vast tracts of its flat roof were also here surveyed, tracts which when covered with canvas, looked like immense fields of snow, and when uncovered, resembled a sea of ice. From this point also the situation and bearings of the whole building became appreciable, and its position with reference to the Park, and other portions of the district in which it was placed, might be accurately estimated. From this position a photograph was taken, of which the engraving at the head of Chapter III. forms the representative, although under the manifest disadvantage of diminished size, which has rendered the details less distinct than in the original. The attentive study of the building, from this point of view, formed an admirable introduction to a general description of it.

An interesting view of the Exhibition Building might be obtained also from the north- or south-west angles.

The full breadth of the structure might here be duly appreciated, and the eye was carried, with pleasing effect, along the tiers of terraces, glittering with blue and white, down to the glassy vault of the transept, the semicircular roof of which gleamed brilliantly in the light of a declining sun. The full length of the building was, however, only in part appreciable. A singular effect was perceived on looking at the building from a position opposite either the western or eastern façades. The central columns only appeared to possess perfect perpendicularity, those on either side appearing to incline, very slightly, to each side. The same effect appeared in the photographic views taken from this position. The height and length of the edifice were well seen from a spot near the Royal Humane Society's receiving house on the north bank of the Serpentine. The graceful outline of the whole was here agreeably broken by clumps of trees, but these also tantalized the spectator, by denying to him the opportunity of an entire view of the building. From the "Deer Park," verging upon Kensington Gardens, a very interesting view was also obtained, and the industrial palace presented, in its light and aerial character, a striking contrast to the residences in front of which it was erected. From the narrow lead flat on the summit of the transept, to which few were permitted to ascend, a surprising scene was presented by the building extending in all its vast proportions beneath, and the visit repayed the trouble required to make it. The following succinct account of the structure, published at the time of the Exhibition, from official sources, forms a good summary of facts, many of which have already been noticed in these pages :—

"The principal entrance to the Exhibition Building, is situated in the centre of the south side opposite to the Prince of Wales' Gate, one of the main entrances to Hyde Park.

"The building in its general arrangement resembles the distribution of parts in a cruciform cathedral with double aisles, consisting of a vast nave 72 feet wide, 64 feet high, running from east to west, 1848 feet in length. This nave is crossed at right angles near the centre of its length by a transept of the same width, and 408 feet long. The roof of this transept is semi-cylindrical, the curve commencing at a height of 68 feet. On each side, both of the nave and transept, run aisles 24 feet in width, and 64 in height, with galleries covering the whole width of the aisles at a height of 24 feet from the ground. Beyond these first aisles, and parallel with them, at a distance of 48 feet, are second aisles of similar width, and similarly covered for their whole width with galleries on the same level as those over the first aisles. In order to communicate from one gallery to another, bridges at frequent intervals span the 48-feet avenues, and divide them into courts, each of which has been so arranged as to present an ensemble to the eye of the spectator looking down upon it from the galleries. The avenues of 48 feet, which we have described as thus subdivided, and the second aisles, are roofed over at a height of 44 feet from the ground. The remaining portion of the building consists of one story only 24 feet high; in which there are of course no galleries. Ten double staircases, each 8 feet wide, give access to the galleries.

"In designing the building, care was taken to fix the position of every column at the points of intersection of lines 24 feet apart, crossing one another at right angles, while in the roofing and flooring the squares into which the whole plan has been thus allotted, were subdivided into 8 feet. This arrangement accounts for the beautiful regularity of the lines of the columns, &c., when viewed diagonally.

"Commodious refreshment rooms, &c., were provided around the trees at the northern extremity of the transept, and adjoining open courts towards the eastern and western extremities of the building, where the presence of the groups of trees dictated their location. The offices of the executive committee adjoined the southern entrance. In addition to the southern, or principal entrance, there are two others, one at the east, and the other at the west end of the building. Fifteen exit doors permitted visitors to leave the building.

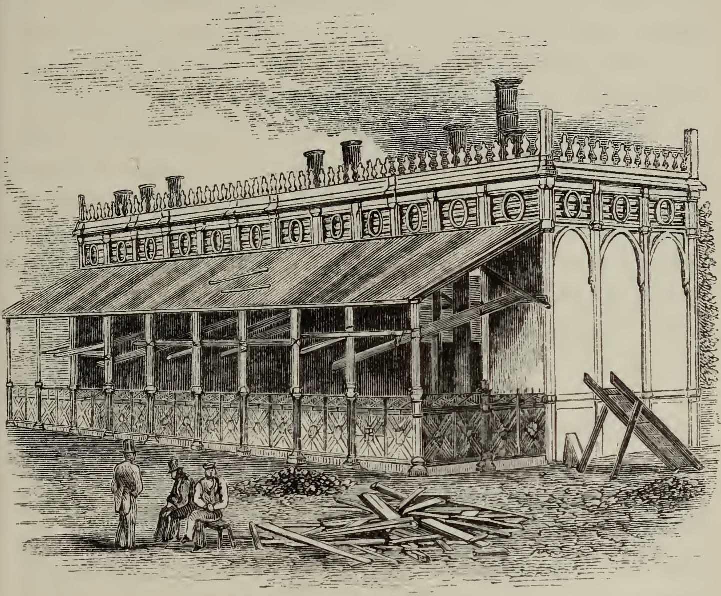
"Water was supplied in abundance by the Chelsea Water-works Company, not only to guard against contingencies by fire, but to supply the numerous fountains which were distributed about the building."

The following statistics also deserve to be remembered:—"The total area of the ground floor is 772,784 square feet, and that of the galleries 217,100 square feet. The galleries extend nearly a mile in length. The total cubic contents of the building are about 33,000,000 feet. There are nearly 2,300 cast-iron girders, 23 feet 4 inches long, and 3 feet deep; and 358 wrought-iron trusses for supporting the galleries and roof; 30 miles of gutters for carrying the roof-water to the columns which support the roof, and 202 miles of sash-bars.

"Of the materials employed,—cast- and wrought-iron, wood and glass, the following quantities were absorbed by this vast work; of cast-iron, it has been estimated that 3,500 tons were used; of wrought-iron, 550 tons; of wood, 600,000 cubic feet; of glass, 900,000 superficial feet, weighing about 400 tons."

Among the many ingenious ideas which were illustrated in the arrangements of the Exhibition, that of the production of motive power by steam-engines exhibited as prime movers, instead of erecting one enormous steam-engine to drive the machinery in motion,—was one. The advantages of this plan were numerous. The steam-engine maker thus enjoyed the advantage of exhibiting the capabilities of his engines, and their peculiar adaptation to the varied wants of the manufacturer, and the sources of power were thus capable of being placed exactly in the position where moving force was requisite, so that all the danger and inconveniences of long shafting and driving bands were obviated. This arrangement also gave to the visitor the advantage of a study of the various species of steam-engines in actual operation, and he was thereby enabled to estimate the respective applicability of these machines to the different kinds of duty they were constructed to fulfil. Engines of continuous action, and of a reciprocating movement, were in full activity, and were all set in motion by high-pressure steam conveyed to them underground from the boiler house, which we now proceed to describe.

The boiler house, which is accurately represented in the annexed cut, taken from a photograph, forms a picturesque structure, imitating, very closely, the appearance of the Exhibition Building itself, although constructed, in large part, on a different principle. It was designed so as to correspond, as closely as possible, with the parent structure, and the resemblance was so great, that a casual inspector might scarcely perceive the differences which existed. It was situated to the west of the building, distant from its north-west angle about 150 feet. Were it not for the low iron funnels which rise from the roof, the intention of the structure could scarcely have been surmised. It was originally planned to have the steam-boilers for generating the high-pressure steam intended to drive the engines in the building, placed in a part of the structure itself, as near as possible to the department of machinery in motion. But the risks of such an arrangement, and the danger of a fire in a building in which the treasures of thousands of exhibitors were to be deposited, proved substantial reasons for the erection of a separate structure. This was effected with great rapidity, but the



THE BOILER HOUSE.

building was not completed by the 1st of May, nor until some time after that date, although the supply of steam and boiler fittings were completed and ready in due time. It must, however, be remarked that the principal risk which would have attended the arrangement of the boilers in a portion of the building itself, was that of fire. The alarm of an explosion occurring, would have been far more formidable than the event itself. The explosion would have affected only one of the fire tubes, as the boilers were on the same principle as those of locomotives, and this accident, which is constantly occurring, is unattended with any very serious consequences.

The boiler house was upwards of 90 feet in length, and 24 feet in breadth. The principle of construction was the same as that adopted in the Industrial Palace —cast-iron columns at intervals of 8 feet and 24 feet respectively, and 24 feet trellis-girders forming the framework of the structure, while, instead of close boarding as an inclosure, brick walls were substituted. It was divided into three compartments, by two brick walls, which support a cold water tank. The compartments, at each end, were for the boilers, the middle compartment being intended for stores. Over the boiler departments the roofing was of corrugated iron. The tank was formed of cast-iron plates, bolted together. It was 21 feet square, and 4 feet 6 inches in depth; and was calculated to hold a supply of about $55\frac{1}{2}$ tons of water. This water was intended for the use of the boilers, the building itself being supplied by a distinct source.

There were altogether eight boilers, all set in brickwork; the largest one was in the middle, and was from the works of Messrs. Galloway, of Manchester; it consisted of two large horizontal tubes or cylinders communicating with each other at a few feet from the front of the furnace, and at the other end by four vertical tubes which passed from the lower to the upper part of the boiler, and ten conoidal tubes for the same purpose. The whole length of the boiler was 13 feet, and the diameter 6 feet 4 inches. The smaller boilers, already mentioned, were of the high pressure multitubular construction, as used for locomotive engines, the flame first acting on the bottom and sides of the boiler, which was supported intermediately by two cross walls, and returning through the tubes towards the chimney, which was fixed at the furnace end of the boiler. The chimney, which was circular, was constructed of iron plates, riveted together: it was 21 feet high.

The boilers received their supply of water from several steam pumps. These pumps were ingenious examples of mechanical construction, being both steam-engines and pumps combined. This engine, technically called a donkey engine or steam-pump, and largely employed for the service of marine engines, was also exhibited in the Building, being the invention of a Mr. Garrett. It was a high-pressure engine of convenient application when the pump was disconnected, or when connected, it was capable of forcing water to any desired height or against any pressure. The same engine is also used to work hydraulic presses, water-cranes, &c. Not more than two of the engines were generally at work, and sometimes neither of them; but this was necessarily entirely dependent upon the rate of evaporation in the boilers, and as these were supplied with transparent water guages, it was easy to adapt the rate of supply to that of the consumption; a standard of general level being fixed for each boiler, and the supply being capable of being turned on or off when necessary, or otherwise regulated in quantity.

The pipes to convey the steam into the "machinery in motion" department were of cast iron, of 8½ inches diameter internally, connected together by flanges in the usual way, and coated externally with felt. The underground channel for these pipes was formed in brick-work, the whole being covered by two over planks.

The conveyance of steam at the requisite pressure from these boilers to the engines, some of which were placed at the farthest extremity of the long area which contained the machinery in motion, was an experiment, the success of which had then to be determined. It appeared at first doubtful whether it could be accomplished, as the distance was so considerable, and the loss by condensation so great. Every method for securing the non-conduction of the heat was adopted.

At certain intervals large globular water-traps were placed which received the condensed steam, and from which it was readily discharged by pipes. But the coating of felt which has been mentioned as surrounding the pipes, proved the most valuable, and, in truth, indispensable element in the success of this attempt. The felt was about an inch in thickness, and was loose and porous in structure, so as to enclose much air, which is, as is well known, a bad conductor of heat. Over the covering of felt was sewn a thick coat of canvas, and this received a coating of paint. By this means a comparatively very small amount of heat was lost by the transit from the boiler house to the engines, although it is obvious that with the best precautions, the amount of condensation throughout so large an extent of piping must have been very considerable. Apart from the necessity for surrounding the pipes with some non-conducting material in order to avoid the condensation, and consequent waste of steam, it was also necessary to prevent the rise of heated air from the steam pipes which were carried under the flooring, through the intervals of which it would have come. And by the means adopted, this was so effectually secured, that it was scarcely perceptible, although the temperature of pipes containing steam at a pressure of 40 pounds to the square inch must have been very high, according to the well known laws regulating the heat of vapours under pressure. For a considerable period the smell of the heated paint was perceived in a slight degree, but no inconvenience arose from this.

The success of this engineering experiment was soon fully established, and sufficient steam was always maintained to actuate all the engines connected with the pipes. Some of the larger engines, such as Nasmyth's steam-hammer, and the marine engines, which required a large volume of steam, could not be supplied, and consequently were not shown in operation. This was much to be regretted, particularly in regard to the former apparatus, one of the most powerful and remarkable of the mechanical agencies of our times. It will be our duty again to refer to this extraordinary mechanism, capable of such delicate adjustment as to fall with a force of 500 tons, or so gently as just to crack, without crushing, an egg-shell. Several pressure guages were attached to the steam pipes, by which the available steam was always readily indicated. It will of course be fully understood that the conveyance of high-pressure steam as thus described, was adopted only on the score of necessity, and is not to be recommended on that of economy.

The erection of any great public building is always attended with a large amount of popular interest, and before it is completed, there are always to be found crowds of visitors inspecting the works and constructive operations. But on no previous occasion has public interest been so generally felt as in the erection of the Exhibition Building. All the circumstances attending it were of a kind well calculated to awaken such a sentiment, and in so vast a city as the metropolis it may be easily supposed that on all available opportunities crowds of its inhabitants would gather around the structure. So soon as the first tier of columns appeared above the enclosure, the greatest interest was excited in a building which gave such early promise of unusual form and elegance, and contrasted in so remarkable a manner with the solid and massive structures in its vicinity. As the building progressed, the degree of attention which it received rose to an extraordinary point, and the Park was thronged with visitors with whom the new and remarkable structure formed an untiring theme of wonder and discourse. Admission to the works was at first denied except to a few privileged persons. But subsequently an admission fee was made. Several hundreds of pounds sterling were thus collected, and were applied to the formation of a sick-fund among the workmen, and also for rewarding special cases of merit. It was not unusual at one period to see from two to three thousand visitors in different parts of the building, but so scattered, that their number could only have been appreciated at the entrance doors. The immensity of the structure appeared to absorb the crowds of men and others employed in it. At dinner time a good idea of their number might have been gained, but at other times it was impossible to form a correct estimate. No admissions were made to the public on Sundays.

This, however, was the principal day on which the external attractions of the building were inspected. And to what an extent this prevailed, may be learned from the following statements given by a competent authority. On Sunday, Feb. 16, 1851, between the hours of two and four, the number of persons passing and repassing the south transept window was at the rate of between two hundred and forty, and two hundred and fifty per minute, or about fourteen or fifteen thousand per hour. On Sunday, Feb. 23, between the hours of two and five there passed through Cumberland Gate, and Apsley House Gate forty four thousand and seventy-six persons.

The progress of the structure was not, however, permitted to proceed without the most violent contentions and paper wars, and every imaginable evil was foretold of it. Although it cannot be questioned that the most scrupulous investigations should always be made into real causes of popular alarm, it is not to be denied that many apprehensions were excited for which no sort of reason existed whatever. As a specimen of the fears entertained by many, may be mentioned one, vehemently contended for in the presence of the writer. Since—it was argued—"the building is made of such slight materials as iron and glass, and is consequently capable of vibration to musical sound, it is only necessary to strike the right note to bring the whole structure down, a heap of ruins." The vast organs which it subsequently contained, the flourish of trumpets, the solemn hymn of thousands, the tones of which went up to the sky, the shouts of the multitude, and the peal of artillery have all been heard, and the structure remained unharmed. But it will be replied, the "*right* note" was not struck!

At a public dinner at Derby, Mr. Fox, one of the contractors for the erection of the building, gave the following account of the sort of objections which had to be encountered in proceeding with the task. "As the building progressed, I was assailed on all sides, not only by unprofessional persons, but by men of high scientific attainments, who, notwithstanding the careful calculations which had been made, and the satisfactory proofs to which all the important parts were individually subjected, as soon as these parts were put together, producing a structure of unparalleled lightnses, doubted the possibility of its possessing, as a whole, that strength which was necessary to make it safe against the many trying influences to which it must be subjected.

"One gentleman, after complimenting me upon the beautiful appearance of the building, stated his belief that it would never come down unless it tumbled down, which he had no doubt in his own mind it would, or that the first gust of wind would blow it down like a pack of cards. Another, holding a high scientific appointment under Government, after a long investigation of the various parts of the building, expressed, at the Institution of Civil Engineers, a belief in the entire want of safety in its construction; and after explaining the mode of connecting the girders with the columns, by means of projections, technically called 'snugs,' went on to indulge in a prophecy that a wind exerting a force equal to 10 pounds per superficial foot, would bring such a strain upon these snugs as to break them all off, and cause them to fall down in showers.

"It may be amusing to enumerate briefly, some of the difficulties and dangers which were foretold. 1. We should never get through our work in time. 2. The foundations were defective, and would surely give way. 3. The building was more like scaffolding than anything else, and was so light that it must tumble down. 4. The weight of goods and people in the galleries would be sure to bring down the building, and if the mere weight did not produce the effect, the vibration caused by people walking, or more especially running, would be sure to do so. 5. The girders expanding by the heat of the sun, would push the columns out of their places, and in so doing, would be sure to break them and let down the building. 6. That if it should happen that the weight and vibration did not produce the effects expected, the equinoctial gales would at all events do so. 7. That if the building was not blown down, the sashes or windows were so feeble that they would assuredly be blown in or out, but it was difficult to say which. 8. That the glass was so weak that it could not resist a gale of wind, but would inevitably be blown to pieces. 9. That if the wind did not act as was expected, firing cannon in Hyde Park, on the opposite side of the Serpentine, could not fail to demolish the windows. 10. That the first hail-storm would leave the whole roof without glass. 11. That by the vibration of the moving machinery, the building would be gradually shaken loose in all its connexions, and must consequently fall. 12. That such were the fears entertained for the safety of the galleries containing the large organ and choirs, that a request was made to Dr. Henry Wylde by some members of the Jury for Musical Instruments, that he would, previous to the inauguration, urge upon my mind the necessity for an investigation into the results likely to ensue from the effect of the vibration which would be experienced during the performance of the National Anthem. 13. That the vibration caused by the diapason pipes of the large organ would shake out the glass which would fall in showers upon the heads of the spectators, and our Chairman was accordingly instructed by the Commissioners to make experiments with the view of ascertaining what the result would really be, and these experiments were officially made on the day previous to the opening."

It cannot be said that all these apprehensions were unreasonable, although they fortunately turned out to be unfounded. A building on such a scale was as yet an untried experiment, and no data existed to show whether the theoretical principles involved in its construction were sound or otherwise. Such a building might be very well suited to the purposes of a conservatory in which no danger of sudden vibrations, and no teeming crowds of visitors would be collected, but it had yet to be shown that it was in every respect adapted to the varied purposes and trials of stability to which it would be subjected as the building for the Exhibition. And it is to be acknowledged that the frequency with which accidents of a fatal and alarming nature had occurred in structures dependent for their stability upon girders of cast-iron, had no small share in producing the feeling of uncertainty which influenced many minds, and was partaken in by distinguished members of the Royal Commission.

It has been shown in a previous part of this work that every possible precaution had been taken to ensure the soundness of the materials employed. Every column, girder, and casting was subjected to a careful examination, and diagonal bracings were introduced so as to give additional security to the whole when put together. It was, however, objected, and perhaps with a degree of force, that, however strong the individual parts of the structure might be, the same parts when united together might not be found equally secure as a whole. In addition to imperfections of material there might be imperfections of construction. It was necessary to set these objections as far as possible, at rest. Among the loudest were the opinions that the girders were insecure, and the galleries consequently in danger of coming down on being subjected to any great strain or pressure. It was determined to put these opinions to the test of experiment. This was effected in the following manner: the account is extracted from a daily paper of the time of the trial, a few alterations being made where necessary.

"Those persons who have been led by the publication of opinions of architects and others, to the belief that the galleries of the building of the Exhibition were not sufficiently strong to bear the load that would in all probability be put upon them, will be happy to hear that that point has been most satisfactorily tested.

"Yesterday (Tuesday) morning, at a little before eleven o'clock, a highly interesting experiment was made, with a view to ascertain practically the strength of the galleries, both under the condition of supporting what is technically called a 'dead load,' and also a 'rolling or moving one.' A few simple figures will pretty clearly explain the basis of calculation upon which the dimensions of the several parts composing the galleries have been determined. The points of support occurring at the angles of squares of 24 feet, the area of each 'bay' of gallery is equal to 576 square feet. From various experiments which have been made by Mr. Brunel and by other engineers, it has been found that the average weight of a number of persons standing together in a confined space rarely exceeds 50 pounds per square foot; that by packing men as closely together as possible, it might be brought up to 70 or 80 pounds; and that not even by picking heavy men, or squeezing them into the smallest compass, could an average of 1 cwt. per square foot be obtained; 1 cwt. was, therefore, assumed as an amount certain to cover any unforeseen combination of circumstances. On this assumption no bay of gallery 24 feet square could possibly be called upon to carry a load equal to 30 tons. As it was ingeniously contrived by the arrangement of the flooring that this weight should be distributed over four girders, and every girder had been submitted on the ground to a pressure of 15 tons, that being only half the maximum weight that each was capable of supporting, applied exactly at the points upon which the floor would have to be borne, it will be manifest that a very large margin had been left to provide for contingencies arising from any motion which it was possible might be communicated to such a load.

"The immediate object of the experiment yesterday was to assure, by various tests of the severest character, to what extent oscillations could be conveyed to the gallery by the regular motion of a living load, and to ascertain whether the provisions which had been made to meet such contingencies were sufficient.

"The preparations made for the experiment consisted of the construction of a perfect bay of gallery, with its floors, tie-rods, girders, and connecting pieces, in every respect complete, and similar to the actual gallery, supported upon four points, bedded on temporary foundations. Rows of planks, the full width of the platform, led up to it, and down from it, so that a row of men, as wide as the gallery, might be able to march up and down in close column. Three hundred workmen were first assembled by the contractors, and allowed to cover the platform and the planks connected with it. They were then compressed into the smallest space upon which they could stand.

"The load borne on the planks represented the share of pressure which would be produced by the crowding of adjacent bays of gallery. The amount of deflection produced by this load was inappreciable. The men then walked regularly and irregularly, and ran over it. The elasticity of the floor, allowing play to the timbers and the wrought-iron work, was admirably developed by this test; and it became apparent that this quality of elasticity was of the greatest value in protecting the cast-iron girders from sudden shock.

"Thus, in the severest test which could possibly be applied, when the men standing closely packed together, continued jumping simultaneously for several minutes, although in the regular vibrations of the floor the tie-rods played up and down, the extreme deflection of any of the girders did not exceed one-fourth of an inch. As the contractors' men were unable to keep military time in their step, and it was considered desirable to ascertain the effect of perfectly regular oscillations, the whole of the corps of Royal Sappers and Miners on the ground, set in close columns, were marched several times over and around the bays, and were finally made to mark time in the most trying manner. With the result of this last test, the eminent scientific men present expressed themselves highly gratified, observing that while at the climax of vibration, the motion did not exceed that common in ordinary London houses at evening parties. A minute examination of the platform, made immediately after the completion of the experiments, showed that no part of the construction had in any way suffered injury.

"When it is remembered that the arrangement for the Exhibition in the galleries require passages only six feet wide on the sides of the gallery, counters for light goods occupying the central portion most liable to strain, and when it is borne in mind that the galleries are of such extent as to render uniform vibration over any considerable proportion of their whole area impossible, the results of the experiments we have described cannot but be looked upon as calculated to relieve the apprehensions of the most timid."

The performance of this experiment was honoured by the presence of her Majesty, his Royal Highness Prince Albert, the Prince of Wales, the youthful members of the Royal Family, and the Royal suite. There are obvious objections however to this experiment, which were so strongly urged by some persons, that it became necessary to give them the attention they demanded. It was urged that the trial ought not to be considered a satisfactory one, inasmuch as the planks leading up to the gallery served as buttresses to it, and prevented that vibration and oscillation which would have been felt had the test been applied continuously to a further extent of gallery. On the part of those, on the contrary, who considered the test as satisfactory, it was contended that the load which was borne on the planks leading to and from the gallery represented the amount of pressure which would be produced by the crowding of adjacent bays in the gallery. Practically to settle the question as to the effect of the vibration of a moving weight along the gallery was the object of experiments of a somewhat different kind. For this purpose a square frame, containing thirty-six compartments, was placed upon the ground, and a 68 pounder shot was placed in each of the divisions, the shot resting upon the floor of the gallery. Upon the top of this frame were piled six others of a similar construction, in each of which was placed a similar number of the shot, making the total number two hundred and fifty-two, the weight of which was 17,136 pounds, or rather more than $7\frac{1}{2}$ tons. The shot thus placed was drawn, by means of pulleys and levers, along the centre of a large portion of the gallery, and notwithstanding this very severe test, no sensible deflection or vibration was produced.

In reply to a question put at a meeting of the Society of Arts, whether the probable effects of the vibration of the machinery had been considered?

Mr. Fox said, that so little apprehension did he entertain on that score, that he proposed to have the bands of the machinery attached to the columns themselves. Indeed, so little did he fear on the subject, that he should be most happy to have a locomotive engine run along the gallery.

A more severe and satisfactory test of the security of the galleries was that which was supplied by the circumstances of the opening day. On that day no person within the vast edifice who contemplated its long galleries filled to overflowing with spectators, could entertain a fear that if they endured such a test, they would be found inadequate to meet future emergencies. That day showed the success and certainty of calculations reduced to practice, and in the most complete and effectual manner demonstrated the skill and accuracy which had watched over the construction of this great building. But a test yet more severe was to be endured by the galleries before the close of the Exhibition. On Tuesday, October 7th, not less than ninety-three thousand, two hundred and twenty-four persons were assembled together in the building at one time! Every avenue, every inch of space appeared to be occupied, and the galleries were so crowded as scarcely to afford room for passing and repassing. The vibrations of those numerous footsteps which paced along them, and the ever-varying pressure of the moving crowd, had no effect whatever upon the stability of the galleries. On one occasion, when a great military officer entered the building thus crowded, the risk of a fearful accident appeared to be imminent, for he was recognised by the crowd, and multitudes thronged at one instant to the front of the galleries. Happily no harm ensued, but the greatest anxiety was for a few minutes experienced by the authorities in charge of the structure.

The effect of the wind on such an extensive surface as that presented by the building was also a subject of anxiety to many interested in its success. At the meeting already alluded to, in reply to the question of a member, Mr. Fox gave the substance of the following remarks, which set the subject in a very satisfactory light.

The building rested on one thousand and sixty columns on the ground floor, and the most likely direction for the wind to have any injurious effect on the building must of course be in the direction of its greatest width, which was 1,800 feet as compared with 400 in the opposite direction. These columns rested on cast-iron plates based upon concrete; and there was no possibility of their rocking about without the base plates being broken. Above these plates were sleepers that carry the floor. They were 13 inches in depth, and fitted accurately up against the two sides of the column, and running transversely from one side of the building to the other; so that it would be very difficult to conceive that one of these columns could be possibly upset until it was actually broken in two. And again, at the top the columns were united together by cast-iron girders 3 feet deep, and four columns were framed together, very much as a table would be framed. Now, to break the column, they must exert a force equal to that of twice the transverse strength of the column. According to experiments, it was found that 6 tons was the bearing weight, and 12 tons the breaking weight of the columns in the centre. Now one thousand and sixty columns, multiplied by 6 tons—the bearing weight, was equal to 6,360 tons; so that it would be necessary to exert a force equal to 6,360 tons at a height of 24 feet from the ground, before the wind would be able to blow down the building, and this computation regarded the building independent of its bracings. The greatest force of wind ever known had been computed at 22 pounds to the superficial foot. Taking 28 pounds as the force, and assuming that they could have a gust of wind which would strike the whole side of the building from top to bottom at the same moment, the total force which could be brought against it would be from 1,400 to 1,500 tons. Now there was a power to resist it of 6,360 tons, not taking into account the bracings, and the other constructions and offices which were within the building, and which must of course add to its strength. The building had been tested in a gale, when Colonel Reid ascertained that the force of the wind was 19½ pounds, and it did no harm whatever; and that was at a time when the roof was not on, and the building was quite exposed.

Another strongly urged objection was made to the strength of the glass used throughout the building, and which was deemed to be insufficient as a preservative against hail. Mr. Fox's reply to a question on this subject is very instructive.

He said he thought the glass quite strong enough, or he would have made it stronger, because he had to keep the glass in repair for the next twelve months. But there was one important point connected with glass which few considered when they put questions regarding it. They only asked what thickness it was. Now its thickness was very important, but the width was equally so. If they got a piece of glass of a certain thickness and width, and found that the hailstones broke it, let them reduce the width, and they would find that it would bear the force of the hailstones. Now the panes used by his firm were 16 ounces in weight to the foot, 49 inches long, and 10 in width. During the last twelve years they had used upwards of 30 acres of glass, spread all over the kingdom, a great deal of it being used at the Royal dockyards, and at Railway stations. It had almost all been 16-ounce glass, and some was as low as 13-ounce; and although the period of the trial was spread over twelve years, they had no difficulty with it whatever. But if, instead of 10-inch width, they had made it 15, they would have had it broken in every hail storm.

It was not long before these points were in some measure satisfactorily decided by the course of the elements themselves. On Thursday, Jan. 16, 1851, a violent gale set in, and assailed the building with furious gusts, which threatened to test severely its general stability. A daily paper thus alludes to the circumstance.

"On Thursday evening the gale was at its height, the gusts, however, struck but a small portion. The continued roar which they kept up as they travelled along the ridges of the roofs, the exposed surfaces, and the long aisles and passages, was exceedingly grand, and the most sceptical, as they heard wave after wave of the wind pass through and over the vast structure, without feeling the slightest vibration in it, must have confessed that the trial was perfectly satisfactory. Repeated objections have also been taken to the thickness of the glass, and several imaginative minds have already pictured to themselves the scene of dismay and confusion which will probably be presented during the Exhibition, when some fierce storm having swept away the thin covering of glass, shall rain its hailstones upon the jewels and silks displayed to admiring eyes, amid the shrieks and cries of assembled thousands of all nations. The elements appear last week to have satisfactorily disposed of these points, for, in addition to the storm of Thursday, the numerous visitors to the building were, on Friday, suddenly roused by a most fearful rattling upon the whole of the roof and sides of the building, which proceeded from one of the most violent hail storms with which the metropolis has for some months been visited. But not a single square of glass was destroyed or injured by its effects."

A singular accident appears to have been produced by a gale of wind which at one period assaulted the structure,—a quantity of glass was displaced from the roof. "No cause whatever could be assigned for it at the time, for although the wind had been blowing somewhat strongly, still it was nothing like the force with which the building had previously, in its more unfinished state, been tested. The glass was not blown in, as might have been expected, from the effects of a violent gust, and it was generally supposed to have been the effect of an eddy of wind. The accident is supposed by some to have arisen from a current of wind running up the side of the building, and the outer ridge of the roof, and passing off at the same angle, creating a vacuum in the valley; the air consequently rushing from below, threw back the sash-bars and the glass, they not being sufficiently secured, in the manner in which some portions of them were found after the occurrence. The damage done was of comparatively trifling character, and the whole was repaired and properly secured in the course of two or three hours."

Perhaps one of the most formidable objections was that of the danger of leakage from the roof during wet weather. And for this there existed the strong argument of actual experience. For a considerable period the leakage was very great. In every direction, after a heavy shower, might be seen the unquestionable evidence of its having penetrated the roof at numerous points, and the most serious apprehensions began to be entertained as to the expediency of a covering so treacherous and little to be relied on, as glass. There can be no question that in principle the roofing was good, and it was difficult consequently to assign a sufficient cause for its numerous defects. The subject assumed such importance as to engage the special attention of the Royal Commissioners, who instructed a competent engineer to examine into the cause, and to report on the matter. From inquiries made, it appeared that the defects were not due to any error in the principle, but in the method of constructing certain parts of the roof. A great number of panes which had been broken had not been repaired, and in many places the panes had not been put in with sufficient care, owing to the haste or negligence of the glaziers. The immense extent of the roofing considered, it was found on the whole, that the leakage was not more than on these grounds could be explained and remedied. Unfortunately, it also happened that the contractors were prevented by the heavy rains from repairing and giving the final coat of paint to the roofing, so that every disadvantage existed at the time alluded to. On one occasion, during a heavy shower, a considerable quantity of water found its way into the building, near the entrance on the south side; upon taking up some of the horizontal pipes in order to discover the cause, a long piece of matting was found in the interior rolled up, and wedged up tightly with pieces of wood, in such a manner as effectually to stop the passage of the water. A portion of the inconvenience which was felt in consequence of the wet coming through the roof, was no doubt traceable, to a great extent, to this obstruction. The efforts to discover the parties concerned in this mischievous act were unsuccessful.

After the canvas was on, the leakage was remarkably diminished, and if we consider the vastness of the surface covered over with glass, it may be regarded as remarkable that it was lessened to the degree ultimately attained; and which was not probably less than would have been experienced in any structure of similar size, made of brick or wood. The effect of a heavy shower passing over the building was very singular to the visitor within the structure. The sound of raindrops falling on the wide expanse of glass was very remarkable. It produced a curious and indescribable feeling in those who heard it. It was not loud, so much as subduing and overpowering, and in some respects it resembled that of a continued wave breaking on a shingly beach. On standing close to some of the columns, the water might be distinctly heard rushing down inside it, and in its course producing a gurgling, trickling sound.

This may not prove an inappropriate place for a few remarks upon the drainage of this vast edifice. The immense horizontal area of about 18 acres, from which it was necessary to carry off the water in so complete a manner as to obviate its accumulation in any spot, presented a difficulty in itself not the least formidable of the numbers which were encountered in the construction of the building for the Great Exhibition. The passage of a drop of rain-water from this roof to the ultimate channel which carried it from the building into the main road was one of some interest, and required a vast amount of careful calculation and pre-arrangement. It has already been shown how so small a matter as the wilful obstruction of one of the pipes was attended with the most serious results so soon as a heavy fall of rain came on. The pipes, in technical language, "blew up," or, in other words, the pressure of the superincumbent column of water, forced open the junctions, and covered the front of the floor around the column with a flood of water. Such accidents not unfrequently happen in house drain-pipes, and their disagreeable consequences are well-known. It was of the greatest moment to obviate such an occurrence in the Exhibition building, when a sudden irruption of water might have done incalculable mischief in some localities, as among the watches, or silks. In order to ensure the rapid and easy removal of all the water falling on the roof, it was necessary to form a correct arrangement of pipes of due size, which should not be obstructed or gorged by the largest amount of water resulting from the heaviest storm of rain.

A drop of water falling on the roof of the building may be thus traced. Falling first on the canvas, or on the glass, as the case may be, the incline at which the panes were set would direct its course rapidly to the gutter, over which the edge of the panes projected slightly. The semicircular form of the latter being found greatly to facilitate the movement of fluids, it would then be placed in the most favourable position for proceeding on its course. In order to direct its path, the gutters were bent upwards, or in technical language "cambered" up in the centre, so as to present a somewhat arched form. The direction of the flow would consequently be influenced by this, and on each side of the centre it would be different, a drop falling on the one half would run this, and on the other, in the opposite direction. Pursuing one or other of these directions, it would enter the square gutters placed at each end of the Paxton gutters, which were supported by the hollow iron columns. The further progress of the roof-water has been described in the following accurate terms, in the "Illustrated London

News." It may be noticed before proceeding further that the sectional area of the Paxton gutter is about 5 square inches, but it opens into the transverse or box gutters, the sectional area of which is $27\frac{1}{2}$ square inches, an increase rendered necessary by the increased flow of water the latter has to conduct.

"The iron columns which support the various gutters act as so many rain-water pipes, in conveying the water from the roof into the cast-iron drain-pipes, running in parallel lines along the whole length of the building, and which have each a sectional area of $28\frac{1}{4}$ square inches. Thus it will be perceived, that as the stream from its fountain-head, increases gradually until it widens out into a mighty river, so the system of drainage pursued in the model structure, for the use of all nations, following nature as its guide, presents the gradual increase of sectional area until it reaches the capacious culvert, which finally discharges itself into the intricacies of the sewers of the great metropolis.

"The principal drain, or more properly culvert, runs along under the ground at the east end of the building. It is of egg-shape, or oval; its height being 2 feet 6 inches, its width 2 feet, and length 390 feet, to its junction with the metropolitan sewer under the carriage-drive on the south side of the great building. To the same outlet, a similar culvert, from the central transverse drain, runs under the same road just outside the outer line of the footpath, having a fall of 1 in 288, and extending altogether 855 feet.

"The main cross drain is placed 24 feet to the east of the central transverse line of the building, is 18 inches in diameter, extends 294 feet southward, and has a fall of 1 in 240. This cross drain is continued by a 24-inch drain, having a similar inclination to the last, and running into the culvert in front of the building, a distance of 190 feet.

"The next to be noticed is a 12-inch drain-tube, extending westward under the same road, the rate of inclination being 1 in 288, and its whole length being 964 feet to its junction with another sewer. At the west end of the building, a 12-inch drain-pipe, 156 feet long, extends from the central line of the building to join the 12-inch drain-tube under the road.

"On the north side of the building, and running eastward, is a 9-inch tube in connexion with one of the lines of 6-inch cast-iron pipes, 348 feet long, and falling one in 192. Then there is a 12-inch drain also, on the north side of the building, 672 feet in length, and returning southward 78 feet; and further extended in the same direction 144 feet, to meet one of the lines of longitudinal 6-inch cast-iron drain-pipes.

"Finally, there are 38 6-inch inlets from the bottoms of columns to the drain on the north side of the building, and which completes the entire system."

In addition to the danger of leakage and heavy showers of rain was another, which in the minds of some persons assumed no slight importance. This was the effect of the alternations of temperature upon the building. It has been proved by careful experiments that a bar of iron of 812 inches in length, when at the temperature of freezing, would expand to 813 inches, if its temperature were raised to boiling point, or 212° Fahrenheit. And though the increase of temperature might be considerably less, it would still be very sensibly felt in the length of such a bar. An interesting illustration of this is also presented by the Britannia Bridge, which, as is well-known, is a rectangular tube of wrought-iron. It is found that the difference of temperature between summer and winter will (in the heat of summer) cause the expansion of the tube, by about 12 inches; or in other words, the tube is 12 inches or 1 foot longer, on a hot summer's day, than on a frosty day in winter. In that instance this difference of length is provided for by fixing the middle of the tube on the Britannia pier, and allowing the ends to rest on forty-eight rollers of about 6 inches diameter in the abutments, the rails in these parts being allowed to slide by each other. These facts being popularly known, it was important to learn in what way, or whether at all, the difference between the summer and winter temperature had been provided for in the case of the Exhibition building, a structure of materials even more rigid and unyielding than those of the Britannia bridge. To this subject of inquiry the following reply was given by Mr. Fox.

The whole extent of the surface covered by the building, from centre to centre at each end, was 1,840 feet, and the width of the general rectangle of the building 408 feet. The total difference in length of a cast-iron bar 408 feet in length between the extremes of summer and winter would be about $1\frac{1}{8}$ inch. The building was divided into two by the nave, which ran from end to end, the only connection between the two sides being the wrought-iron trusses and the roof. The greatest difference in the total amount of motion in expansion or contraction which could by any possibility take place in the perpendicularity of the columns from the effects of a change in the atmosphere, would be about a quarter of an inch, while it would be perfectly safe to bend any of the columns to the extent of 2 inches at the least. In order to provide for a requisite degree of stiffness in the building, they had determined that the expansion and contraction should be entirely provided for by the elasticity of the columns themselves, which were all 'keyed up' hard and fast together, for distances of 200 feet at each end of the building, and for a similar distance upon each side of the transept. The girders would have the opportunity of sliding upon the brackets which supported them. The flooring of the galleries, which ran the whole length of the building, as well as the Paxon gutters which formed the girders, served as a continuous wooden tie, leaving the cast-iron in a condition to expand according as it was acted upon by the various changes of the atmosphere.

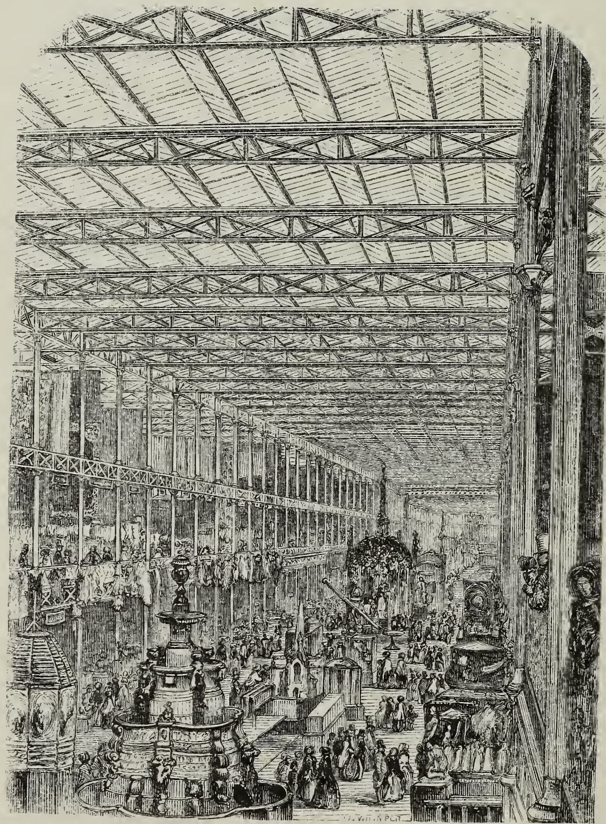
On the same occasion the inquiry was made as to the security against fire, and as to the insulation of parts in case any of the materials contained in the building should be accidentally ignited.

In reply to which, Mr. Fox stated, "that before making any arrangements for supplying the building with water, he called upon Mr. Braidwood, who had the management of the fire brigade of the metropolis, and asked him what class of buildings he considered the safest against fire; and Mr. Braidwood said he should like the walls to be of lath and plaster, and the roof of glass. He also stated that he considered all the old notions about making buildings fireproof by using non-combustible materials, a mistake. 'You failed in getting what you wanted, because if you used cast-iron girders, when they got hot they broke, and wrought-iron rods would fall down by expansion from the heat; and if you wished a building that you could get at soonest, and with the greatest facility ascertain where the fire existed, a glass roof was the best, because as soon as the fire began to burn, the glass would crack and fall, and let the flames out at the roof, and unless there was an unusual amount of wind prevailing, the fire could be very much confined temporarily in that portion of the building. Having lath and plaster sides they could easily be broken through, and steps be taken to extinguish the fire.' He (Mr. Fox) said to Mr. Braidwood, 'You recommend lath and plaster sides, what would you think of glass?' Mr. Braidwood said he would like it better, that then he could see where the fire was at once, and knowing what he was doing, could pour water upon the fire; and that he should think a building with a glass roof and glass sides the safest building that could ever be put up. Now it had been necessary to have wood all round the lower tier of the building, and at intervals all round on each side to have exit doors, of which there would be nineteen or twenty. They were to have on each side a glass window, so that in the event of fire they could at once see any portion where it existed and extinguish it. And for the purpose of obtaining a proper supply of water, the Chelsea Water Works Company were building a 9-inch main, with a column of 70 feet constantly on it, and a 6-inch pipe running across the building; also a 6-inch pipe running round the whole of the outside of the building, together with sixteen branches from the outside pipe running into the interior of the building, and by which with one length of hose, and without the aid of a fire engine, they would be able to control the whole surface of the building. A special arrangement had been made with the Chelsea Water Works Company for the water to be always on; and the company had been at the expense of an additional auxiliary engine for the purpose of ensuring a constant supply; whilst in ordinary cases they were bound to supply 300,000 gallons per day. With regard to the collection of shavings underneath the floor, they had been strictly ordered to be all swept away by the workmen, who had positive directions that no part should be covered until the ground had been completely bare."

It is a gratifying fact that only on two trifling occasions was the smallest alarm ever really felt as to fire during the Exhibition. On one of these instances, a slight ignition of some materials took place in a corner adjoining the offices of the Commissioners. The accident was immediately discovered, and all danger was over in a few minutes. More alarm was produced by an almost ludicrous occurrence which took place during this period. In order to render active assistance in the event of a fire, one of the machines known as the Fire Annihilators, of large size, was placed in the vicinity of the transept. Owing to some derangement of its mechanism, the gases, which it is capable when put into action of producing, were developed, and the machine exploded, giving vent to a cloud of smoke and steam, which at first produced a feeling of alarm of fire. No fire, however, existed, and it was a source of much amusement that the alarm had been created by an instrument especially intended to extinguish flame. The burning of the greatest city of ancient or of modern times would not have produced such an effect throughout the world, as a general conflagration of the Exhibition building, and it may be regarded as one of the instances of the gracious over-rulings of Divine providence, which in a special manner attended this event, that a calamity so fearful never occurred.

We have thus traced out the varied difficulties which attended the construction of this great edifice. Difficulties, in some instances, not necessarily arising out of the mere mechanical obstacles to be encountered, but those of a less tractable nature, which had their origin in the apprehensions of the popular mind, and which, whether originating in well founded opinions or otherwise, proved, nevertheless, harassing and discouraging in no small degree. It is a happy circumstance for all interested, that the dark forebodings which attended this constructive experiment, have none of them been realised; that neither the air, nor the water, nor the fire, which threatened destruction in the thoughts of many, has executed that task, and that the building passed unharmed through a short but eventful history; pregnant, indeed, with perils, none of which were by God permitted to befall it—of which no other structure presents a parallel example.

CHAPTER VIII.



OPENING OF THE GREAT EXHIBITION.*

HITHERTO we have been occupied chiefly with the Exhibition building, considered apart from the object

* The cut exhibits the western main avenue, looking from west to east.

for which it was erected. The origin, progress, and completion of this structure, have formed the subject of these pages for some chapters back, and it now becomes necessary to restore to its real position that event, in comparison with which the mere preliminaries become insignificant. And this stage of our subject introduces us to scenes which the pen of history must render memorable so long as the world remains. The work of construction, so far as the building was concerned, had been completed for some time; but the fixing and arrangement of the fittings, counters, and stands, in itself a task scarcely less arduous, had yet to be accomplished. The quantities of rough timber absorbed in this part of the works were immense, equalling if not surpassing those required for the actual edifice. A long low plain deal counter being supplied by the executive, and at their cost, it remained for individual exhibitors to gratify their own tastes in erecting more costly fittings for the display of their productions. This was a part of the unavoidable arrangements over which the authorities could exercise little or no control, and it unfortunately happened that the great majority of exhibitors deferred their own fittings almost to the last hour. The confusion which thus arose was tremendous. Every one was busy at the same moment, in completing what might have been readily completed in good time, but for a universal spirit of procrastination. It will scarcely be believed by those who were eye-witnesses of the order and regularity which distinguished the great event of May 1st, 1851, that the following account contained in a paper published only five days previously could be true, although in fact it is rather an imperfect than a complete view, of the distracting disorder which then existed.

"On Monday next the preparations on the part of exhibitors are to be completed. The galleries are to be cleared: the shavings are to be swept away; the hammering is to cease—all is to be ready for public inspection. Looking upon the scene yesterday, it appeared utterly impossible on the part of exhibitors to comply with these orders. Thousands of men, of all nations, were busy, after their several fashions, but on every side arrangements were far from complete. In some of the foreign departments little more than the counters were erected; and only on the British side could be seen large compartments in a condition of completeness. The throng of visitors yesterday was very large, and ladies were seen edging their way through piles of planks and packing-cases, with the evident determination of seeing everything. In the transept, bands of men were rolling articles in from the great doorway; men were giving the finishing touches to the statues: crowds of workmen were hovering about the great fountain; Turks and Egyptians, Prussians and Frenchmen, were chatting vigorously; policemen were repelling intruders into wrong departments; exhibitors of all kinds were discussing their grievances or good fortune; ladies were asking the precise positions the principal personages who are to figure in the state ceremonial were to occupy; and above all workmen were preparing to cover the glass with canvas. It was a bright and animated scene. In the vastness of the space, the moving crowds looked like ants; while the thousand hammers, the blows of which resounded from all sides, added to the confusion and the half-bewilderment. Looking down the galleries from the transept, the view presented the characteristics of a gigantic eastern bazaar. Huge tapestries, carpets, and brilliant linens and silks, hung down from the galleries in every direction, and of every form and colour. Here the perspective is intercepted by a huge organ, there by a gigantic statue, and elsewhere by an altar window of splendid stained glass. In the western avenue the way was yesterday so blocked up with wood-shavings and empty packing-cases, that it was hardly possible to arrive at any idea of its artistic effect. Workmen were carrying the arms and heads of statues about; an industrious gilder was busily employed upon the nostrils of her majesty's horse; five or six carpenters were upon a gorgeous bed in the galleries, nailing up ornaments; inquisitive visitors were trying the tones of bells; a musician was testing the monster organ; while two or three Greeks were attending to their departments, carpentering and adjusting their articles, *in gloves.* In the galleries, the exhibitors of the light goods of all nations were in a fever of excitement. In the refreshment rooms, exhibitors of all countries, male and female, were regaling themselves, or hurrying away to work again. In every part of the vast building it was evident that there was not a moment to be lost—and that every minute was of precious value. The grand confusion in four short days must assume an harmonious form—the chaos be reduced to order. At one door, packing cases in vast heaps were being ejected into the road; and the sappers and miners might be seen perched upon hills of deal boxes calling to the drivers of wagons and carts. Studded about the main avenues were artists, with their desks and wood blocks, calmly drawing various objects.

The reception of goods at the building proved a source of vast confusion, and demanded the most thorough arrangements in order to overcome the obstacle thus occasioned to the completion of the work of fitting up the Exhibition. The whole route from Hyde Park to Charing Cross was filled toward the expiration of the time for receiving goods, with vehicles of every description, conveying objects of different kinds, carefully secured in packing-cases, to the Exhibition building. The accumulation of vehicles in the road presented at this time a singular and exciting spectacle, and contributed greatly to add to the popular interest in this event, which had already attained no common degree of intensity. It was necessary to name April 10th as the last day on which goods, unless specially excepted, would be received in the building, and on April 2nd, the entrance for wagons and carriages was to be closed. The following is an extract from the official notice placarded at the entrances.

"RECEIPT OF GOODS—*Final Notice.*—1. On Wednesday evening, the 2nd of April, the temporary entrance into the building for carts, wagons, and carriages of every description, will be closed, to enable the flooring of the building to be completed; and no articles will be admitted into the building which cannot be brought in by hand, and without the aid of machinery for lifting, &c. Even such articles cannot be admitted if they should exceed the width of the entrances—namely, 6 feet, 6 inches. 2. After the 3rd of April, no packing-cases will be admitted within the building. Any articles brought to the Exhibition between the 3rd of April and the 10th of April must be delivered unpacked, and in such a way as to cause no litter in the building; in fact, they must be delivered as they would be brought into a private residence. 3. On and after the 3rd of April, any articles sent through carriers which require to be unpacked, will be deposited outside the building, and remain there until the owners or their agents attend to unpack them, &c. And finally—7. the Executive Committee particularly request that all goods may be finally arranged on Monday, the 21st of April, in the way it is proposed they should be exhibited, in order that the Executive Committee may then proceed to having the building put in order for the admission of the public."

Exhibitors who delayed beyond that period sending in their goods, were to be subjected to heavy fines. The most stringent regulations failed to effect the desired end, and quantities of goods were admitted only a few days prior to May 1st. In fact, during the whole period that the Exhibition remained open, fresh goods were continually received and exhibited up to the last few days of its career. The following table, dated just four days before the opening, appears to deserve preservation as a statistical record of the number of foreign and colonial goods in packages received up to that date at the building.

FOREIGN.

Belgium	1,050
Brazil	1
China	238
Denmark	63
Egypt	49
France	3,329
Germany: Austria	638
North: Hanover	11
,, Hamburg	125
,, Lubeck	3
,, Oldenburg	3
Zolverein:—	
,, Bavaria	83
,, Baden	2
,, Hesse	101
,, Nassau	14
,, Prussia	1,072
,, Saxony	144
,, Saxe Meiningen	5
,, Wurtemburg	137
,, Frankfort	38
Greece	18
Holland	226
Italy: Naples	3
,, Rome	27
,, Sardinia	87
,, Tuscany	96
Mexico	4
New Grenada	1
Peru	4
Persia	1
Portugal	109
Russia	251
Spain	233
Sweden and Norway	29
Switzerland	153
Tunis	203
Turkey	3
United States	907
W. Africa	9
Haiti	2
Society Islands	1
Total	9,473

COLONIAL.

Australian Colonies:—	
New South Wales	12
South Australia	29
Van Diemen's Land	80
New Zealand	42
Bermuda	4
Canada	345
Cape of Good Hope	37
Ceylon	9
Hong-Kong	19
India	446
Malta	49
Mauritius	1
Nova Scotia	35
St. Helena	4
West Indies: Antigua	1
,, Bahamas	9
,, Barbadoes	5
,, British Guiana	16
,, Grenada	1
,, Jamaica	3
,, Montserrat	2
,, Trinidad	21
Total	1,172
Channel Islands:—	
Guernsey	10
Jersey	23
Total	33

ABSTRACT.

Foreign	9,473
Colonial	1,172
Channel Islands	33
Total	10,678

In this table it will be observed the number of British goods is not included; but it considerably exceeded the number here given as the total for those of foreign and colonial exhibitors. Probably not fewer than twenty thousand packages were received prior to the first of May, and these it was necessary to open, to remove, and to leave the contents in due order in the space already marked out for their reception. Immense obstruction arose toward the last, from the mere accumulation of packing-cases, the removal of which many exhibitors left to the authorities of the building. Large bills of the following tenour were placarded in the building with scarcely any result, as exhibitors appeared to prefer sacrificing their cases to being at the trouble of taking them away.

"All packing-cases, &c., must be removed by the agents, exhibitors, &c., as soon as they receive orders from the Executive Committee to do so. Packing-cases not removed within six days after notice has been given will be sold by the Executive Committee, and the proceeds applied to the funds of the Exhibition."

The act of removal was at length undertaken by the authorities, and countless packing-cases were ejected, from the building, and cast into a great heap outside the western façade. In very many instances even the duty of unpacking was obliged to be fulfilled by the sappers employed by the executive, exhibitors having, either through misconception or neglect, failed to send any person to see to their goods. It is a curious part of the history of the Exhibition, that the first article received was a trifling article of dress—a bonnet or a cap, sent from some country exhibitor.

The appearance of the packing-cases containing goods of different nations was not the least singular part of this extraordinary scene. The addresses on these objects were often extremely curious, and even ludicrous, as may be imagined from the following specimen. "Sir Vyatt, and Sir Fox Hendersen, Esqrs., Grate Exhibition Building, Hyde Park, in London. *Glace* softly, to be posed upright." And almost every case was inscribed fragile, with the addition of a rude figure of a wine-glass or a jug depicted upon it to give force to the term. From the external inspection of these cases, the spectator might have supposed that glass and porcelain would constitute by far the largest portion of the articles exhibited. But on opening the cases, a very different list of contents would have been made out.

The arrangement of articles in the building formed a very perplexing subject of consideration at a time long prior to the opening, and for some time it was uncertain whether a philosophical or a geographical plan would be adopted. To this, however, it will be necessary to refer further on, when we come to take a general survey of the contents of the building. But the secondary question of putting each article as received into the place already assigned for it, was a task the most disheartening and confounding. Prior to the admission of any articles into the building, it was necessary that the proprietor should, through a local committee, have received a voucher specifying the amount of space he was permitted to occupy. The following is Mr. Henry Cole's account of these arrangements.

"The 31st October, 1850, was appointed the last day when the Local Committees were required to transmit to the Executive Committee the demands for space which intending exhibitors had made through them.

"It then appeared that the whole of the demands for horizontal (floor and counter) space in the building, which the Local Committees of the United Kingdom returned, exceeded 417,000 superficial feet of exhibiting space, being in excess of the amount of available space for the United Kingdom by about 210,000 superficial feet. The amount of vertical or wall space demanded was only 200,000 superficial feet. The number of persons who proposed to exhibit was upwards of eight thousand two hundred.

"Upon the receipt of these data the commissioners proceeded to adjust the proportions of floor or counter-space, which it appeared desirable that the four sections of the Exhibition should occupy in the building. Upon averages, furnished by the whole of the United Kingdom, and obtained by dividing the total amount of space apportioned to each section by the number of exhibitors in that section, the commissioners, as a general rule, allotted to each Local Committee an amount of space in each section, in proportion to the number of exhibitors which had been returned by each committee. The commissioners left the allotment of space to each exhibitor absolutely to the discretion of each Local Committee. They desired that each Local Committee, in allotting space to the individual exhibitors, should, as far as possible, maintain the proportions of the four sections allotted to it, so that in the ultimate arrangement of the whole Exhibition, the space which each section might occupy, should agree as closely as was possible with the spaces fixed by the commissioners. It was suggested that only those articles which did honour to our industrial skill as a nation should be admitted, and that the industry of the district should be represented with perfect fairness, so as to do the fullest credit to its industrial position.

"The commissioners then proceeded to cause copies of each individual application for space to be transmitted to the respective Local Committees for revision and correction where necessary, which, when returned by the Committees, were considered as the vouchers for the admission of the articles, and as tantamount to *their unqualified approbation of the articles.*"

In order to fix the exact position of each exhibitor on the British side of the building, the space allotted to him was marked out in red paint on the floor, and the work of arrangement of the articles as they arrived was thus rendered more easy than in the absence of such a system. The vastness of the whole work was, however, such as to overturn, or rather overwhelm, every arrangement made beforehand, and in reality, in many instances, the articles were put in their places as convenience or expediency might direct; a certain general classification being as far as possible maintained. As a general rule applicable both to foreign countries and the United Kingdom, space was allotted on the following data:—on the ground floor each area of 24 feet by 24 feet, containing 576 feet superficial, was accounted as yielding exhibiting area of 384 feet, it being considered that 192 feet would be a sufficient allowance for passages. The width of these was determined by experiments in the building and by experience of those in the British Museum, in the Soho Bazaar, &c. In the gallery, half of each area was deducted for passages, and the other half, or 288 feet, assigned as exhibiting space.

The few days of the week before the opening, found the Exhibition building a scene of bewildering confusion, and given up to thousands of workmen, attendants, and exhibitors. It would appear that owing to a very general feeling, produced by unavoidable delays in the completion of the building, it was very generally believed that the Exhibition would not open, as originally intended, on May 1st. This might be taken as an explanation of the reluctance of the exhibitors to complete their arrangements at an earlier period. Truly, the aspect of the building on the Monday and Tuesday of that week, appeared to promise labour for a month to come in reducing the confusion that then reigned into order. The Royal

Commissioners were very properly inflexible, and refused to defer the opening. It was, perhaps, only on the Tuesday that this became really a matter of belief among exhibitors generally; and at that period, when it became evident that the time would not be extended further, a tremendous struggle was made, and the most violent efforts were now used to redeem time irrecoverably lost. Every one was behind, and the great day was close at hand; no pen can adequately describe the scene. A lively French writer, M. Jules Janin, gives the following graphic picture of the scene the day before the opening.

"*Fervet opus!* The work grows and advances with giant steps. You have seen in the warm rain of the month of March the bare tree clothe itself in one day with budding leaves; it seems as though we actually saw the verdure grow. Well, so in the Crystal Palace is seen to spring up on all the walls, at the corner of every avenue, a crop of splendid works swathed but a few moments back in the holland and brown paper of the bale-maker. It is the effect of a magician's wand, and the French portion is especially remarkable for the ease and rapidity with which the wand is obeyed. The space, which but now was empty, when you pass a second time you find filled by France. She waited till the last moment—her invariable custom—and then went ahead. At this very moment—and I have just left the spot—nothing is done on our side, nothing is ready, and yet nobody appears anxious, so certain is it that we shall be ready to-morrow. This is our strength. And it is our motto, '*Toujours prêts!*' The most complete branch of the Exhibition at the present moment is the American; it is complete; it is largely and solidly established. Order reigns in the American exhibition; but it is open to one objection—namely, the want of objects to exhibit.

"It would be vain to attempt a description of the noise, the tumult, the cries, the eagerness, the activity, the zeal, which are everywhere manifested. At the Tower of Babel there were as many various tongues spoken, but people were far from understanding each other as well. No paltry rivalries between nation and nation, but each, on the contrary, striving to assist the other. During the whole day the building is open to visitors, but the sightseers, mingling with the workers, are found to impede nothing and no one. The policemen lend a helping hand to the foreigner: the soldiers of the engineers' corps—the only soldiers admitted into this pacific arena—are occupied in unpacking all the packages which are coming in with pellmell haste. There is nailing and unnailing, unfolding and fixing, hanging and stretching, painting, scrubbing and polishing, writing of labels, and hot haste everywhere. In the finest place in the transept, between the two trees, buried in a massive group of rhododendra and fresh-blown roses, rises the throne of Her Majesty the Queen. On each side of the throne springs up a jet of water descending into a marble basin; a range of statues forms both an avenue and a *cortège;* an amphitheatre of benches, covered with velvet, await the spectators of this festival, which is about to render illustrious the month of May."

It is to be added, however, for verity's sake, that this writer's opinion of the state of the French department, and its undoubted readiness in sufficient time, was so far from being correct, that a period of six weeks at least elapsed before the goods were arranged in the order, and with the exquisite taste afterwards exhibited. The English, though late in preparation, were punctual by the appointed time; but the French, and many foreign exhibitors, were very far behind. At an early hour on Wednesday afternoon the building was cleared in a systematic manner, and only a few persons were permitted to remain, who took part in the final arrangements. The night came on, but the task of preparation was only partly accomplished, and it was necessary to labour all through that night in order to set all in readiness for the event of the next day. At an early hour the next morning the writer was in this wonderful building, now decked out in its fully-developed glories, and the contrast could scarcely have been believed to be real, so rapidly and in so complete a manner had order taken the place of disorder, and effective arrangement of a bewildering disarray. The spectacle which that day presented we can scarcely hope adequately to describe.

It is an interesting fact, noticed in a periodical devoted to antiquarian researches chiefly, that Chaucer, who wrote in 1380, has described in quaint terms, what appears to offer a curious parallel with this event and its particular circumstances. In a poem called the House of Fame, the following passages occur.

"As I slept I dreamt I was
Within a *temple made of glass*,
In which there were more images,
Of *gold* standing in sundry stages,
In more rich tabernacles
And with *jewels* more pinnacles,
And more curious *portraitures*,
And quaint manner of figures
Of gold work than I saw ever."

. . . .

"Then saw I stand on either side
Straight down to the doors wide
From the dais many a pillar
Of metal that shone out full clear."

. . . .

"Ther gan I look about and see
That there came ent'ring in the hall,
A right great company withal
And that of sundry regions
Of all kinds of conditions
That dwell in earth beneath the moon,
Poor and rich, and all so soon
As they were come into the hall
They gan on knees down to fall
Before this same noble queen.
'Madame,' said they, 'we be
Folk that here do beseech thee

That thou grant us now good fame
And let our works have a good name
In full recompensation
Of good work give us good renown.'
Such a great congregation
Of folks as I saw roam about,
Some within and some without
Was never seen nor shall be no more!"

Early in the morning of Thursday, May 1st, 1851, the transept floor was covered with red cloth, and the north approach to it was similarly carpeted in a broad line, along which the Queen was to enter the building. And a broad strip of matting extended the entire circuit of the building. In the centre of the transept, the removal of a hoarding exposed to view the magnificent crystal fountain of Messrs. Osler, now visible for the first time, its brilliant and iridescent pillars reflected in the basin below. The first performance of this splendid mass of cut glass was to take place on that morning. By cords from the vaulted roof of the transept, was suspended a beautiful silken canopy, at an altitude of 30 feet above the dais on which the queen was to take her seat. The colour of this beautiful ornament was blue, and it had a rich fringed border, ornamented, at intervals, with ostrich feathers of a pure white. Seats were arranged around the transept to a considerable height, for the accommodation of privileged spectators, and along the entire length of the building, in the galleries, and on the ground floor, were similar means of accommodation for the majority of visitors, who were unable to obtain a nearer position. At this time of the morning, not a sound was audible throughout the vast structure, in which, for months past, the noise of the mallet and the hammer overpowered the ears, and scarcely a single individual was visible, where, on the preceding day, it is calculated that not fewer than ten thousand persons had been, all busy in the work of preparation. The appearance of order was complete, and it is difficult to convey, by any terms of expression, the overpowering sensation produced by the contemplation of the vast edifice, then awaiting in silence the first influx of an army of visitors, to be counted, to posterity, by millions. The spot on which the queen was to be seated was marked by a raised dais, in the centre of which a splendid chair, selected from the Indian collection, was placed, being covered by a magnificent scarlet velvet elephant cloth, richly brocaded with gold. The centre of the dais was carpeted by the carpet wrought by the united labours of one hundred and fifty British ladies, and presented to her majesty; being subsequently exhibited by her. These were all the preparations made for her reception, being simple enough in themselves, but acquiring magnificence and grandeur from the gorgeous scene in which they were placed.

It may be necessary here to mention that it had been originally intended to open the Exhibition in private, only a few persons being present. But a strong appeal having been made, Her Majesty ultimately consented to make the event of national and historic interest by a state opening, and, above all, by a solemn dedication of the whole project to the glory of God the Creator and Giver of all. It was then arranged that all persons who had purchased season tickets, the price of which, it may be mentioned, was three guineas, and two guineas, for gentlemen and for ladies respectively, should have the privilege of being present on this interesting occasion. The effect of this announcement was to give an almost incredible impulse to the sale of these tickets, which, until then, had proceeded but slowly, and, in a short time the whole of the first issue had been purchased, and a second was commenced. An attempt was now injudiciously made to advance the price of them, but it was almost instantly abandoned, and the original price preserved.

But few of those who had purchased these tickets were willing to lose the spectacle promised, by every circumstance, on the 1st of May; and for some hours before nine o'clock the time of opening, every entrance to the building was besieged by applicants for admission.

As the clocks in the Exhibition struck nine, the gates were thrown open, and the temple of industry was, in a short space, more crowded with living beings than was ever the temple of the sun of old, in its day of dedication to idolatry. Such a scene can never be witnessed again. A few moments before, and the vast space was empty; and now, only a little while had elapsed, and beheld it filled, and still filling fuller and closer. From every entrance a tide of visitors streamed in, and separating, penetrated every vacancy in the building, near the course of the procession. The galleries were filled to overflowing, the transept was likewise so filled, except in those parts preserved for the entrance of the Queen, and the vast nave, 1850 feet long, had scarcely a vacant space in it, which was not occupied either by some animate or inanimate object. At half-past eleven, the doors were closed, and the building may have been literally said to have been filled, although, in actual numbers, it contained more, by many thousands, on subsequent occasions, but these were distributed through every part of it; on the present occasion, twenty-five thousand persons were gathered together along the nave, in the transept, and in the front of the galleries. A considerable number of workmen and others were collected together on the flat roof on either side of the transept, who, by looking down, enjoyed a singular and wonderful spectacle.

In the northern half of the transept, and grouped around the throne, were assembled the Royal Commissioners, Her Majesty's Ministers, the Executive Committee, the Diplomatic Corps, and a large number of other distinguished persons, in court, military, or civil array. Interest was also given to this assemblage by the appearance of a Chinese mandarin, in the native costume, who appeared very much at home in a scene which to him, of all the rest, must have been fraught with sources of wonder and surprise. As the hour for the arrival of Her Majesty, twelve o'clock, approached, public expectation increased to a degree painful in its intensity. The scene which, as that hour struck, was then presented, cannot be better described than in the following graphic terms. "The hour hands of the clocks with which the Crystal Palace is decorated, were approaching twelve, when the faint huzzahs of crowds outside, announced that the queen had arrived; the booming sound of a royal salute, from across the Serpentine, struck faintly on the ear, and then a loud flourish of trumpets from the north gallery of the transept, told that Her Majesty had entered the building. She was conducted at once to a robing room. Thence, after a short pause, and attended by her court, she proceeded between flower stands and tropical plants, past the Colebrook-dale gates, and the fountains and statuary with which that part of the edifice is adorned, to the throne in the centre. On her appearance the vast assemblage rose to welcome her, a burst of enthusiastic cheering broke forth from every side—ladies waved their handkerchiefs, gentlemen their hats, and the whole scene presented was one of unusual splendour. The sun, too, for a moment emerged from the envious clouds that for some time previously had dimmed his lustre, and a flood of light pouring in through the glittering dome of the transept, illuminated this imposing spectacle of loyalty. When Her Majesty ascended the throne, attended by the royal family, and the distinguished visitors of her court, the organ of Messrs. Gray and Davison pealed forth the notes of the National Anthem, and the immense choir collected for the occasion, accompanied the strain. This produced a grand effect, and not a heart present could remain unmoved at a scene so touching and so sublime. His Royal Highness Prince Albert, when the music had ceased, joined the Royal Commissioners, who drew near to the throne, and read to Her Majesty the report of the commission."

On the conclusion of this report, which embodied a short retrospect of the proceedings of the Royal Commissioners, of the labours of the contractors, executive, principles of award, &c., the Prince handed to Her Majesty a copy of the report, and a catalogue of the articles. Her Majesty returned a short answer, and the next and most important proceeding was that of solemnly dedicating the Exhibition, and the objects for which it had been instituted, to the glory and praise of God alone. The following appropriate and beautiful prayer was offered up by the Archbishop of Canterbury:—

"Almighty and everlasting God, who dost govern all things both in Heaven and in earth, without whom nothing is strong, nothing is holy, accept, we beseech Thee, the sacrifice of praise and thanksgiving, and receive these our prayers which we offer up unto Thee this day on behalf of the kingdom and people of this land. We acknowledge, O Lord, that Thou hast multiplied on us blessings which Thou mightest most justly have withheld. We acknowledge that it is not because of works of righteousness which we have done, but of Thy great mercy, that we are permitted to come before Thee with the voice of thanksgiving, and that instead of humbling us for our offences, Thou hast given us cause to thank Thee for Thine abundant goodness. And now, O Lord, we beseech Thee to bless the work which Thou hast enabled us to begin, and to regard with Thy favour our purpose of knitting together in the bonds of peace and concord the different nations of the earth; for with Thee, O Lord, is the preparation of the heart in man. Of Thee it cometh that violence is not heard in our land, wasting nor destruction within its borders. It is of Thee, O Lord, that nations do not lift up the sword against each other, nor learn war any more; it is of Thee that peace is within our walls and plenteousness within our palaces; it is of Thee that knowledge is increased throughout the world, for the spirit of man is from Thee, and the inspiration of the Almighty giveth him understanding. Therefore, O Lord, not unto us, not unto us, but unto Thy name be all the praise. While we survey the works of art and industry which surround us, let not our hearts be lifted up that we forget the Lord our God, as if our own power and the might of our hands had gotten in this wealth. Teach us ever to remember that all this store which we have prepared, cometh of Thine hand, and is all Thine own. Both riches and honour come of Thee, and Thou reignest over all. In Thine hand it is to make great and to give strength unto all. Now, therefore, O God, we thank Thee; we praise Thee and intreat Thee so to overrule this assembly of many nations that it may tend to the advancement of Thy glory, to the diffusion of Thy holy word, to the increase of general prosperity, by promoting peace and goodwill among the different races of mankind. Let the many mercies which we receive from Thee dispose our hearts to serve Thee more faithfully, who art the author and giver of them all. And, finally, O Lord, teach us so to use those earthly blessings which Thou givest us richly to enjoy, that they may not withdraw our affections from those heavenly things which Thou hast prepared for those that love and serve Thee, through the merits and mediation of Thy Son Jesus Christ our Lord, to whom, with Thee and the Holy Ghost, be all honour and glory."

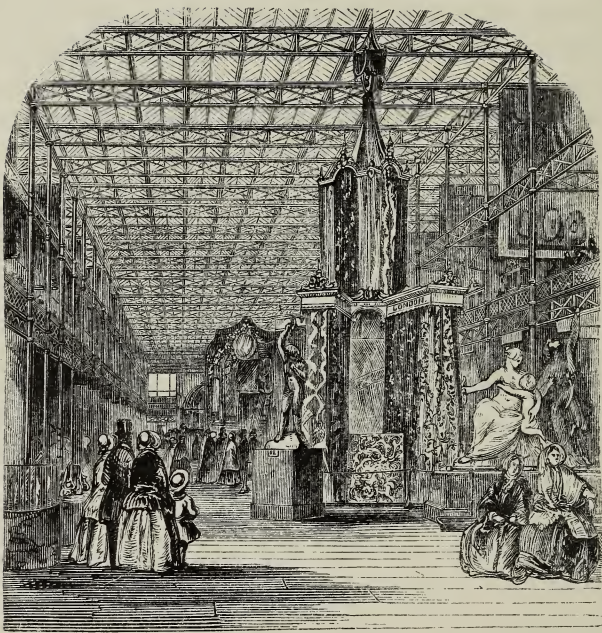
Few who know the future history of the great event then opened, can doubt that that prayer, offered up in the midst of twenty-five thousand of the human family, went up to Heaven, and received again and again an answer of grace and peace. Deep indeed were the ingratitude to deny that He whose aid was thus sought in an undertaking, to many minds fraught with perils, granted the blessing asked by His praying people, through the alone mediation of His beloved Son. And the pious mind will delight to trace the manifest overruling of Divine Providence, over every future circumstance of the history of the Great Exhibition of 1851. It deserves remark that many Christians had, before this event, made the subject, which every day assumed more of a national character, one of united prayer, and the Mighty Answerer of prayer fulfilled the highest anticipations of His servants in the prevention of every danger, and in conducting the whole to a happy and peaceful close.

On the conclusion of this prayer, the choir joined in singing the Hallelujah chorus, the strains of which were heard through the glassy roof, by the crowd outside. The procession for making the circuit of the building, then formed, and consisted of a large assemblage of distinguished persons, preceding and following Her Majesty the Queen, who led the Prince of Wales, and His Royal Highness Prince Albert, who conducted the Princess Royal. To many present in that building, on that occasion, this was an affecting and impressive spectacle. To see the highest personage in the realm confiding in the love and loyalty of her people, and requiring no force of arms to shield her progress, was to behold a picture, of which no other country could afford the parallel; and whatever may be the opinions of many as to the results of the Exhibition itself, there can be little doubt that this spectacle alone was productive, if of no other feelings, of one of the greatest admiration and respect for this country and its institutions. Many there present had been spectators of scenes yet fresh in memory, of a far different nature, enacted in other lands, and, to these, this realization of the blessings of willing subjection to the laws, and of order and peace in society at large, cannot have been idly passed by. A very interesting group in this procession, was formed by the Duke of Wellington and the Marquis of Anglesey; the former in his eighty-second year, who, with trembling steps, walked arm-in-arm around the building. As the procession passed on its course, the various organs pealed forth the national hymn, and to those who were in positions near the transept, a remarkable conception of the extent of the building was derived, from the fact that at this point the tones of the most powerful instrument there, which was placed at the western end of the nave, were absolutely inaudible, and even the applause of thousands of spectators, could only be surmised by the waving of hats and handkerchiefs, which marked the position of the royal party.

And now the last act of the ceremonial remains to be recorded. The Marquis of Breadalbane, in a loud tone of voice, announced that the Queen declared "the Exhibition open." A flourish of trumpets proclaimed the fact to the assembled multitudes. The royal family, attended by the court, withdrew from the building, the choir once more took up the strain of the National Anthem, the barriers, which had hitherto restrained the spectators within certain limits, were withdrawn, and the long pent-up masses poured over every part of the building, eager to gratify their curiosity.

Such was the first and state opening of the Great Exhibition, an event which, without attaching to it undue importance, or expressing an opinion on its merits, is, henceforth, one which the historian cannot pass lightly by. Such a scene will never probably be again presented to the contemplation of mankind, until that period, long foretold in the word of God, shall have arrived, when people of every nation, kindred and tongue, under heaven, shall be summoned to the presence of the King of kings and Lord of lords, that Divine and exalted Saviour, once crucified for man, and then returning to call the whole earth to His judgment-seat. Happy they who may abide the day of His coming, who can stand when He appeareth, and with the confidence of a true faith, exclaim, on his arrival, "this is our God, we have waited for Him, and he will save us."

CHAPTER IX.



THE INDUSTRY OF NATIONS AS EXEMPLIFIED IN THE CONTENTS OF THE GREAT EXHIBITION.*

In illustration of the subject of this chapter it is not intended to do more than give a superficial sketch of the contents and arrangement of articles in the Great Exhibition, pointing out, where necessary, the national characteristics of each collection. All those matters of detail which will justify their description at fuller

* The cut represents the main avenue looking westward from the transept. The silk trophy is in the foreground.

length will receive notice in other portions of this work. It has been felt throughout this book, that since this event has assumed a national character, it has thereby acquired a distinct historic interest, demanding a careful and accurate account, in order that others who may come after, may be enabled to form a just idea of that which this generation has been permitted to behold. The history properly so called of this event, cannot receive its full treatment in these pages, but it remains to be written,—for every catalogue and guide-book fails to give its complete and satisfactory development. The reader's indulgence may, therefore, be expected in the description of scenes and circumstances, which, however familiar to him, are yet to be told to our children. We have been, on this account, careful to present such facts as by personal knowledge could be certified, and have endeavoured to give an accurate, though condensed view of the whole, from its first conception to the remarkable events of May 1, 1851. It is in further pursuit of the same object, which will now soon cease to engage our attention, that we desire in the present chapter to give a rapid glance of the interior and contents of the wonderful building whose construction and completion has so long occupied our thoughts.

The principles adopted in the arrangement of the contents were thus generally described by Mr. Cole:—

"The systems of classification of the goods of exhibitors which had been adopted in the French Expositions proved that any arrangement based upon an abstract philosophical theory was unsuitable to the present Exhibition. It was also felt to be of importance that the system of classification should be made conducive to the readiest mode of consulting the vast collection, both by the general visitor and by the 'juries,' who would have to consider the merits of the whole in order to the award of the medals, &c.

It was ultimately decided to adopt a sectional subdivision of the Exhibition into Raw Produce and Materials, Machinery, Manufactures, and Fine Arts, and each section had the several classes arranged under it in those subdivisions which had been determined by commercial experience. Eminent men of science, and manufacturers in all branches, were invited to assist in determining each one the boundaries of his own special class of productions; and it was ultimately resolved, for the purposes of the jury, to adopt thirty divisions, or classes, and to induce as far as practicable the application of this classification to all articles—both British and Foreign; as a rule, however, the productions of an exhibitor were not separated, except in very extreme cases. Accordingly, with few exceptions, all articles were divided into the following thirty classes.

SECTION I. Raw Materials and Produce,—illustrative of the natural productions on which human industry is employed.

1. Mining and Quarrying, Metallurgy, and Mineral Products.
2. Chemical and Pharmaceutical Processes and Products generally.
3. Substances used as Food.
4. Vegetable and Animal Substances used in Manufactures, Implements, or for Ornament.

SECTION II. Machinery for Agricultural, Manufacturing, Engineering, and other purposes and Mechanical Inventions,—illustrative of the agents which human ingenuity brings to bear upon the products of nature.

5. Machines for direct use, including Carriages, Railway and Naval Mechanism.
6. Manufacturing Machines and Tools.
7. Mechanical, Civil Engineering, Architectural, and Building Contrivances.
8. Naval Architecture, Military Engineering and Structure, Ordnance, Armour and Accoutrements.
9. Agricultural and Horticultural Machines and Implements (exceptional).
10. Philosophical Instruments and Miscellaneous Contrivances, including processes depending upon their use, Musical, Horological, Acoustical and Surgical Instruments.

SECTION III. Manufactures, — illustrative of the result produced by the operation of human industry upon natural produce.

11. Cotton.
12. Woollen and Worsted.
13. Silk and Velvet.
14. Manufactures from Flax and Hemp.
15. Mixed Fabrics, including Shawls.
16. Leather, including Saddlery and Harness, Skins, Fur, and Hair.
17. Paper, Printing, and Bookbinding.
18. Woven, spun, felted, and laid Fabrics, when shown for Printing and Dyeing.
19. Tapestry, including Carpets and Floor Cloths, Lace and Embroidery, fancy and industrial Works.
20. Articles of Clothing for immediate, personal, or domestic use.
21. Cutlery, Edge Tools and Hand Tools, and Surgical Instruments.
22. General Hardware.
23. Works in precious Metals, Jewellery, and all articles of luxury not included in other classes.
24. Glass
25. Ceramic Manufacture, China, Porcelain, Earthenware, &c.
26. Decoration Furniture and Upholstery, Paper Hangings, Papier Maché, and Japanned Goods.
27. Manufactures in Mineral Substances, used for building or decorations, as in Marble, Slate, Porphyries, Cements, Artificial Stones, &c.
28. Manufactures from Animal and Vegetable Substances, not being woven, felted, or laid.
29. Miscellaneous Manufactures and Small Wares.

SECTION IV.

30. Fine Arts, Sculpture, Models, and the Plastic Arts generally, Mosaics, Enamels, &c.—illustrative of the taste and skill displayed in such applications of human industry."

It had been originally contemplated by the Commissioners, that the arrangement of the whole Exhibition should be, not merely on the basis of the four sections, but that each similar article should be placed in juxtaposition without reference to its nationality, or local origin. To effect this, in so vast an Exhibition and within the short period of two months allowed for the arrangement, it was absolutely necessary to know, before the arrival of the articles, the approximate amount of space each would be likely to occupy—so that each on its arrival might be placed as nearly as possible in its appointed spot. But the event proved that this information, particularly in the case of Foreign countries, was unattainable. And in fact, upon mature consideration, it was evident that the greatest confusion and disorder would have arisen had any such attempt been made. It may be questioned also, how far it would have been either judicious or useful, as the idea of gaining information by contrast of the skill of different countries in producing the same article, was wholly impracticable in consequence of the vastness of the display of objects of every kind. No alternative remained but to adopt a geographical arrangement. Circumstances connected with the form of the building itself, the absence of the necessary information from Foreign countries, the great pressure for time, and above all, the importance of punctually opening the Exhibition on the 1st of May, rendered necessary the division of the ground floor of the building into two parts—the one being awarded to Foreign countries, and the other to the British colonies and the United Kingdom.

The productions of the United Kingdom and the British colonies were generally grouped *westward* of the central transept. The productions of each foreign country were placed together *eastward* of the transept —except machinery in motion, which, on account of the motive power being at the *north-west end* of the building, was placed in that part of the building. These objects were, however, very insignificant, and offered but a poor contrast to the splendid display of English machinery. The productions of each country were classified nation by nation, and as far as practicable into the thirty classes already mentioned. The classification of foreign goods was, however, very imperfect, and scarcely deserved the term. The position of each country was determined in the building by its own geographical position. Thus, proceeding eastward from the transept, were China, Turkey, Persia, Egypt, Spain, Italy, France, Germany, Austria, &c. As a general rule, machinery was placed at the *north* side, and raw materials and produce brought to the *south* side of the building. The intermediate parts were occupied by manufactures and fine arts. On the whole this classification worked well. The visitor enjoyed all the variety of a united display of the peculiar productions of foreign countries, and the instruction derivable from a classified and arranged exhibition of those of our own. In the instance of several foreign nations also it was evident that, had their contributions been separated and placed in juxtaposition with those of our own or other countries, their individual importance would have been reduced to nothing. And it was of the first consequence to keep in due prominence the fact, that almost every civilized nation had its representatives at this exhibition. The great attraction evidently offered by what came to be known as the Foreign side of the building was conspicuous from the first, and it appeared a very natural feeling that the visitor should regard with more attention, objects, the peculiar form and treatment of which were altogether novel to him, than such as were daily rendered familiar to his eyes in our own places of trade. The system had its objections and its errors when fully carried out, as it was attempted on the British side. In fact some classes could not be separated, and many might have been better studied, had they been united. In spite of much care in framing the instructions for classification, great mistakes occurred, and it was not until a short period before the final close of the building, that the majority of these were duly rectified. Particular classes, such as Philosophical Instruments, Glass, Porcelain, and Paper being respectively classes 10, 24, 25, and 17, were extremely interesting under this arrangement, and furnished an opportunity for study which may probably never again be afforded.

In order to facilitate the arrangements, and also to afford a ready means for the discovery of any particular object or series exhibited, a simple plan was adopted, which was extremely good in theory; but owing to the absurd way in which the distinctive marks were placed in the building, very few out of the countless thousands who entered it, were really aware of any such method of discovery being in existence. The following is a description of this plan. "The columns are all at distances of 24 feet, or multiples of that quantity. By a combination of numbers and letters,—the building being quadrangular,—applied to every one of these 24 feet spaces, this plan, it was suggested, would so simplify the arrangements that the position of every article in the building would be pointed out with the most perfect ease. Accordingly every space of 24 feet, running from north to south was lettered, the first space on the north side being A, and the last on the south side S. Each space running from west to east, instead of being lettered, was numbered, the numbers running consecutively from 1 to 77. By this plan the visitor entering upon any avenue, say E or P, at the east or west end, if he only continued to walk straight on could always find himself in that letter, and at every 24 feet he would pass into a different number. So again, if the visitor, instead of proceeding east or west, should direct his steps to the north, or south, he would, upon entering any numbered avenue, find himself, if he walked straight on, constantly in that number, while, at every 24 feet, he would pass into a different letter. Nothing, it was said, could be simpler than this arrangement, every 24 feet space had its own notation, and it would be possible, therefore, with the most perfect ease, to identify every spot in the whole twenty acres which the vast building occupied."

It was intended at first to place distinguishing numbers relating to these numerals and letters on the pillars in the catalogues, but this was abandoned, owing to certain practical difficulties which rendered it extremely inconvenient to do so. The letters were so small and indistinct, and placed at such a height from the ground, that it was impossible in many places to discover them, and in many others they were covered by the arrangements of the exhibitors in displaying their goods. A much more simple and intelligible method of marking out the building into its different districts, was the picturesque plan of hanging red banners with inscriptions in white letters from the girders along the sides of the nave, and across the various avenues. It was, by this means, perfectly easy to discover the leading features of the contents of different parts of this great edifice. In order to find out any object in the catalogue, it was simply necessary to look at the class or country, and the exhibitor's number, which were both legibly printed on a card affixed to his goods, and refer by that means to the work which was arranged into classes and countries, giving a distinguishing number to each exhibitor.

The history of this extraordinary work, the catalogue of the Exhibition, is without a parallel in the annals of literature, and it may be worth while adverting to a few interesting facts in connection with it.

When the subject of a catalogue for the Great Exhibition first presented itself to the Royal Commissioners, it appeared enveloped in obscurity. Only time could develop the means of its accomplishment. The fact that about fifteen thousand exhibitors were preparing their goods for exhibition, seemed to render the production of any sort of catalogue a question of the greatest uncertainty. Who was to write, who compile such a work? Who could accurately describe the products of exhibitors, and give to each his name and place, and to each a fair account of the part he fulfilled in the great display? As the year 1851 opened, the subject assumed a definite character; and the agency by which the work was to be accomplished was decided on. A great and novel literary experiment was to be made; and it was resolved that those who furnished their productions to the Exhibition, should likewise supply the record of their efforts. The fifteen thousand exhibitors were to write the book, which the Royal Commissioners would cause to be duly printed and sold. For this purpose every exhibitor was supplied with a paper on which he was required to write a description of his goods, and this manuscript formed in reality the basis of the future catalogue.

Long ere this, however, the copyright of the work had been sold for the sum of 3,200*l.* sterling, of which a large portion was paid down on the ratification of the contract. The book chiefly contemplated by this contract was the small catalogue, a work barely capable of being produced, regard only being had to paper and print, for the sum at which it was to be sold. Another catalogue might, however, be printed, at the contractors' option, to contain illustrations. It was to be a catalogue similar to the other, but with illustrations. It was a book to be written by those who knew more of the counting-house and workshop, than of the intricacies of literary composition, or the requirements of the typographer. The suggestion was then made that very probably many of the accounts written by exhibitors, and involving by necessity the employment of technical or scientific terms, would scarcely form the kind of work likely to be valued by the public at large. In short, it became obvious that some method of treatment must be applied to the rude literary material proposed to be gathered together, if a hope were entertained of rendering it a popular, or a generally useful book.

A definite plan was then proposed, and subsequently successfully carried out. A large number of scientific men, and of those conversant with the arts were invited to contribute explanatory and commentatorial information in the form of notes. The same gentlemen were likewise to correct technical and scientific terms. Here ended their duties. The whole onus of the work, that is to say its literary construction, and general scientific accuracy devolved upon one individual. The manuscripts furnished by exhibitors presented a very unpromising appearance at first, and it seemed almost hopeless to look for the production of a good work out of such materials. There appear to have been two general classes into which the Exhibitors' MSS. might be divided, the British and the Foreign; and peculiar difficulties were presented by each. It requires but a slight acquaintance with the present temper of the commercial classes to foresee the tendency to self-laudation which manifested itself in these papers, and at one time, it is averred, almost threatened the existence of a work necessarily impartial to all. How much of the superfluities of language which were actually found in these accounts were due to a mistaken conception, the elaborate instructions issued by authority for their preparation does not appear, but it is very probable that many commercial men mistook the invitation to communicate information of value and interest, and replied to it in the exaggerated terms of an advertisement. The literary construction of these MSS. must have afforded a singular insight into the educational acquirements of the exhibitors. Some were scarcely able to indite a sentence. Some were wordy, and profuse in descriptions of things of no importance, others were confused, or brief and unsatisfactory. Many were properly written, and correct in composition, but very few had any literary point. Of all these MSS. the most scrupulous care required to be taken, and each was to be duly made fit for public inspection. Some portion of fact existed in all, and the obvious duty was to preserve this, rejecting only what was incorrect and unsuitable. To what an extent this duty has been fulfilled may be best learnt on a careful investigation into the structure of the volumes now known as the Official Descriptive and Illustrated Catalogue, in 3 vols.

The preparation for press of the MSS. of the foreign exhibitors proved to be a most formidable task. It is stated that the whole Belgian catalogue was so badly translated as to require to be entirely re-written from beginning to end, and this, after it had been set up in type. The technical terms employed in MSS. of fair average translation, were almost invariably ludicrously incorrect, and the most extraordinary mistakes were made. It may give the reader some conception of the difficulties of preparing this work, to attach a few specimens of the mistakes found in the MSS. of foreign exhibitors, and which were not unfrequently conspicuously displayed on the stalls of the different exhibitors.

"Iron's pins made as white as silver by some process favoured with patent and Privilege in France and England.

"These Iron's pins have the advantage over those made with brass-wire, to be more nervous, more brilliant, and to have the point more resistant.

"They are besides Sold to the Merchants, Eight or ten per cent Cheaper than the brass-wire's ones."

The next relates to some files.

"The basis of this new process consists in the hardening of the teeth of the files by the very cutting itself, of which results that these teeth have clean shapes and sharp edges which enable them to act as small regular chisels.—These files never cram themselves whatever may be the matter upon which they are worked, they cut that said matter cleanly off instead of tearing it away and instead of cropping as the old files do and consequently gives shavings instead of giving filings.—In short their during much longer and their resisting much better insures them a remarkable and incontestable superiority over all sort of produce of the same kind.——The French patent is worked (only since a few months) by an association, consisting of forty Workmen.

"The superiority of these new files upon those made in France to this day is such that notwithstanding the infériority of our steel and the few progress made in our country as to what regards the tempering and the annealing of steel, these said new files sustain the competition with the best English files, and to such a degree that they are sold the same price that is to say 20 per cent dearer than the best French files."

The next is an exhibitor's account of himself.

"M — having deserved the confiance of English by his conscientious labours, that he finished every day is affirmed that his works will be always received by them with the same kindness and that they will not jumble in the crowd of those who they are treating that part with indifférence and without any inspiration of the art."

We subjoin a few miscellaneous specimens.—

"The merit of the present invention is this: no Mechanism, no spring, not any playing of weels. the Iron-work is that commonly used: hinges and a french Espagnolette."

"Water-proof-Schoes.—The method to attain the proposed object, and render Schoes Complettely Waterproof consists to act in a new manner thé leather and to plaister it in the interior with a solution of cahoutchouc and other ingredients.

"For chase it is good to fix upon these Shoes spatter-dashes of a new-model which are closed by wire, or three buckles and wich are exposed near the shoes."

"Pine apple Soap.—The last mentioned is only produced in this Manufactory. The Smell of this Soap is clear Chemical and not perfumed, and I am the Sole Inventor of it."

"Calf-leather Boots inwardly so formed as to fit a deformed foot.

"Model of a deformed foot for the Boot."

"One stuffed cold without a seam."

"One stuffed goat."

"Artificial Gum Arabic.—It is of various qualities according every use. that wich is employed for printing is sold for 6*d*. per lb. and produces an effect twice more than true gum, it is by this merit reduced to 3*d*. compared to the arabic five times as dear."

Other specimens were as follow:

"Shawl partly all wool.

"Shoe vamps for little boys.

"Ditto for big boys.

"Ditto for small men."

"Coffee and Tea machines from Potsdam."

These amusing errors were repeated all over the foreign department, and a goodly volume might have been collected by any visitor interested in such attempts at translation.

The small catalogue was a work extending, by contract, to three hundred and twenty pages, or twenty sheets of double foolscap folded into eight. The enormous number of upwards of two hundred and sixty thousand copies of this work sold at 1*s*. were disposed of in and out of the building. Each exhibitor's account of his articles did not exceed on the average three lines, and fifteen thousand names of exhibitors are contained in it, including among them the most celebrated names in the European commercial world. The actual price at which this work was produced, was a fraction under 10*d*. for each copy, the other 2*d*. being deducted and applied to the funds of the Exhibition.

That such a work could be sold at such a price, is in itself one of the greatest marvels of the Exhibition, and in a forcible manner illustrates the economy of production which has arisen in consequence of the introduction of mechanism into the factory of the paper producer, and into the office of the printer. About 110 tons of paper were thus absorbed in the form of copies of this book in the space of five months, and the duty payable to Government on this amount was more than 1500*l.* sterling.

The large catalogue, after many delays, originating very greatly in the want of proper arrangements in the Exhibition itself, at length made its appearance in the form of three portly volumes, which contained a large number of illustrations. This work gives in detail the accounts contributed by the exhibitors, with the addition of explanatory and illustrative notes, papers, &c. In addition to these catalogues, were a number of other minor publications also issued by the same contractors, and the amount of type actually occupied by these was not less than 60,000 pounds in weight. The building and its contents were, however, too vast to permit of the proper use of these works as works of reference, except to those who could daily investigate the articles. It deserves to be mentioned before passing to other subjects, that in the case of the small Official Catalogue, one of the most rapid instances of book-production ever known, occurred in its punctual appearance on May 1st. The following is the account given of it.

The classification or arrangement of the Exhibition into their proper subdivision and numerical order began at the printers' just before the arrival of the last corrected slips; which came only two days before the Exhibition would be open, and the Catalogue would be demanded by the public. The small Official Catalogue was classified, made up, printed and bound in four days. The first perfect impression was only produced at ten o'clock at night upon the eve of the eventful opening. Ten thousand Catalogues, properly bound, were punctually delivered at the building, on the morning of the 1st of May! The two copies presented to Her Majesty and to the Prince that morning, elegantly bound in morocco, lined with silk, and with their edges gilt, had been bound, lined, and gilded in six hours. Of course a work so produced was full of errors and wrong descriptions, but its appearance was compulsory, and that it was actually accomplished, must remain one of the many feats of celerity performed in connection with this event.

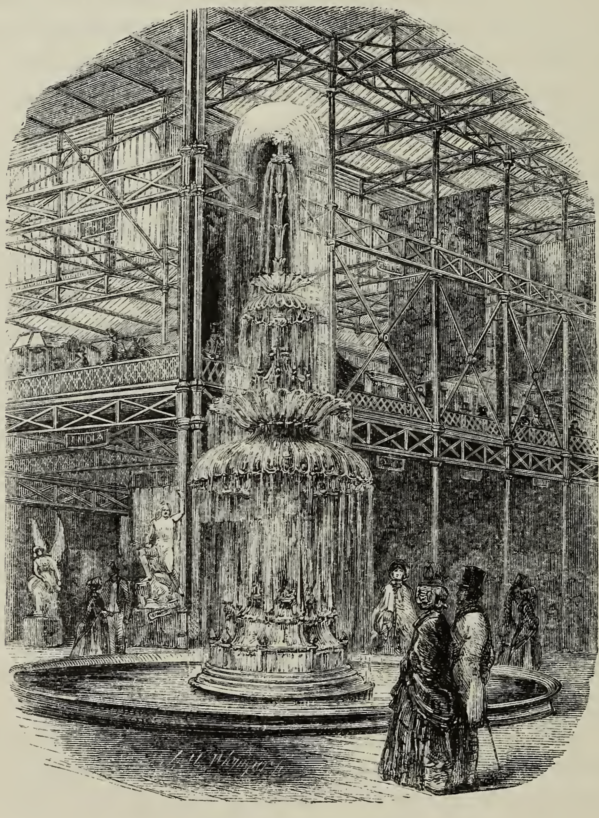
It is necessary now to refer to those wondrous and varied contents of this edifice, and after the information thus detailed, the reader will be able, we believe, even though denied the instructive gratification of seeing the spectacle itself, to form a tolerably accurate conception of its character from the description we propose to lay before him. The transept may be conveniently taken as a point of departure. The contents of this striking feature of the building are well displayed in the accompanying engraving, which presents an accurate picture of the scene in the height of its beauty, about the middle period of the Exhibition. Over this part of the building no canvas had been placed, and a powerful light from above consequently illuminated the whole area, which was always seen in whatever direction the transept was regarded from the sides of the building, as a spot glaring with light, and in all photographs taken of this part, the same fact was remarkably prominent. The transept was arranged rather with a view to the artistic effects of its contents than with any other definite object. It was appropriated to British exhibitors, but its contents were not entirely of one class as in other places on the British or western side of the structure. The scene it presented, the whole details of which had been most carefully studied in order to produce the greatest harmony of combination, was well calculated to impress the visitor

THE TRANSEPT.

who here first entered the building with admiration and surprise. In a blaze of light descending from the transparent roof, were seen groups of statuary at the base of the tall pillars supporting the sides, and tastefully hung with crimson cloth. In the middle space were beautiful plants in flower, with statues placed among them. In the centre stood the great fountain of crystal glass, glittering with the hues of the rainbow, and discharging a flashing jet of clear water, which broke into a shower of drops around its base. Beyond it was a costly and complicated model of a frigate, surrounded by twisted and torn fragments of sails of ships caught in a tropical tornado. Towering above this, and drooping gracefully forwards was the stem of a magnificent palm tree, the great feathery leaves of which hung down from the summit only; and around it were placed the cocoa and other palms, the ribbed and lengthy lanceolate fronds of which formed a most impressive and singular contrast, in the eye of the naturalist at least, with the exogenous character, the knotted and bulky stem and branches, and the comparatively minute leaves of the great elm-tree which stood above them. Beyond these to the north, was another fountain, the jet of which was capable of throwing water 40 or 50 feet high in a shower of the finest rain, so fine as to produce no sound whatever on its return to the basin below. Still further to the north were some small cases of tropical plants, called Ward's cases, beyond which was a very pleasing fountain of cast-iron, and a range of highly ornamental park gates, exhibited by the Coalbrookdale Iron Company, which formed a counterpart to other very beautiful gates for the same purpose, which were placed near the south entrance to the transept, and were the production of other exhibitors.

The clock in the southern gallery of the transept was in connection with the larger electric clock before alluded to, as ornamenting the exterior of this portion of the building. Its construction will on another occasion be brought under notice; but the remarkable appearance of the long hands, with the semicircular form of the hour-dial of the great clock, and the fact that it was connected with the clock in the gallery, and also with one at the termination of the western main avenue by means of two copper wires, all keeping the same time by this means, gives it sufficient interest to be here included among the objects which were deserving of remark in this portion of the building. For some time after the opening day, the silken canopy which overshadowed the spot occupied on that occasion by Her Majesty, was permitted to retain its place, recalling to the memory of the visitor the unparalleled scene he then beheld. The best view of the transept was obtained from a spot in the gallery, immediately over the south entrance doors: the arched roof, with its complex ribs and arches of daring span, was here seen to great advantage, and the great fan-like window at its extremity appeared to form a beautiful termination to the view. The tall elm trees also, which were overleaped by the glassy roof, formed a curious picture, and were strangely placed among the varied objects of art which surrounded them. From the northern gallery of the transept an interesting view, which is represented on a preceding page, was also acquired, and the sound of the water jetting up among the branches of the trees, and falling again into the basins immediately below, gave a peculiarly refreshing sensation to the visitor at this spot. Close to this spot a hive of bees were exhibited in full work, being allowed an exit to Kensington Gardens through a small aperture made in the pane against which the hives were placed. The acoustic effects of the vaulted roof of the transept were singular, and were often to be noticed when the powerful reed-stop of the organ over the south entrance was put in action.

In the arrangement of the objects contributed by British exhibitors, the happy idea was suggested of forming in the western main avenue certain prominent groups of them, which should convey at a glance the importance attached to them in the industrial world. These groups were also arranged with a view to produce a good artistic effect when seen in the position they were intended to occupy. They were called trophies; thus there was the wood trophy, the silk trophy, the chemical trophy, &c. A sort of epitome of the classification of the articles was thus afforded, and the remarkable objects thus arranged along the immense avenue, formed an exhibition of the triumphs of art and industry, in itself highly imposing and instructive. The great crystal fountain



THE GLASS FOUNTAIN.

placed in the centre of this building of glass, formed a suitable trophy to the importance of that manufacture, the results of which lent to the Exhibition building its lightness, and much of its attraction. This might have been called the glass trophy. It is shown in the annexed cut, which is, we believe, the only really accurate representation of this object yet produced. The others will be noticed as we sketch the contents of the western avenue.

Passing from the transept toward the west, the main avenue, with its immense span of flat roof, covered with canvas, was entered. The light was here much softened and subdued, and a singular effect was often perceptible on looking at the canvas-covered roof, in the passing of waves of wind along the canvas, which was thrown into forms of waves, so as to resemble those of a ruffled sea. At the entrance to this avenue were placed objects of statuary in marble and bronze; but the most striking feature of this part of the Exhibition, was the beautiful trophy of silk which was here displayed, and attracted great admiration.

This silk trophy might be taken as the type of the textile fabrics of Great Britain and Ireland. It was originally intended, that, as each trophy would represent a particular class or manufacture, exhibitors in those departments should unite to form a complete type of their trade. Thus, the silk trophy was intended to have been contributed to by the various manufacturers of Spitalfields, and would thus have been a fitting representation of the silk trade in all its branches. Practical and technical difficulties, however, had to be overcome, in bringing together products so varied as those of the loom, even in one material; and one company, as manufacturers of the largest kind of silk goods for furniture damasks, undertook the whole work. Perhaps few others were willing to undergo the immense loss which must necessarily result from the exposure of such costly articles to the light, air, and dust, in such a building as that of the Exhibition.

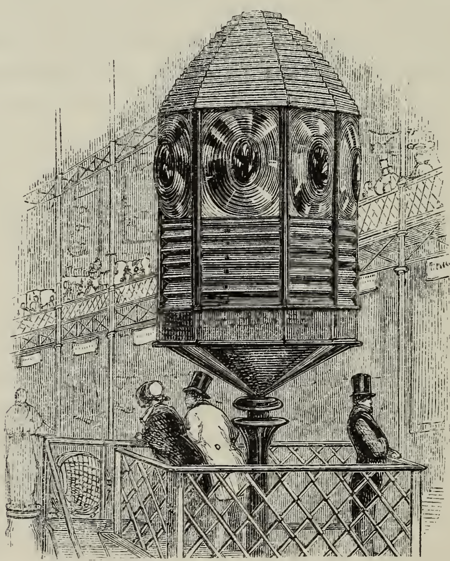
The whole was hung with rich silk damasks, brocatelles, tabarets, &c., to the height of upwards of 50 feet; the sides of the base being filled in with mirrors of the largest dimensions, which were the contribution of other exhibitors, reflecting, at certain angles, the draped arrangement, and surmounted by flags and a banner, the central one being emblazoned with the royal arms. In order to effect the regular re-arrangement of the whole at stated periods, the structure was so contrived, that, by ladders placed inside, the requisite work could be effected with comparatively little trouble in a short space of time. For some time, this magnificent ornament of the western avenue was protected by a covering of calico every evening, but toward the last the once beautiful silks of which it consisted were found to be so much injured, that it was abandoned to its fate, and prior to the actual close of the Exhibition, it was altogether removed.

Beyond this was placed a group in bronze, entitled the Horse and Dragon. Westward of this was the timber trophy. This formed a remarkable group of timber in planks, arranged as effectively as was possible with a small canoe on its summit. One of the portions of this trophy was a block of wood which had undergone a remarkable change of structure, and become partly silicified. At the opposite end of this pile was a fine specimen of the lower jaw of a sperm whale. The trophy consisted principally of planks, &c., from Canada, and was appropriately placed in the centre of the avenue, between the space allotted to this and other colonies on either side. Still proceeding westward, were arranged a restoration of the monument of Philippa of Hainault, carved in a species of alabaster obtained in Derbyshire, and an immense console table and glass; the proportions of which seemed to render it unfit for most edifices, and even for many of large size and public use. A pleasing fountain was next met with, the design of which was intended to illustrate a part of the fabulous history of Acis and Galatea. The water issued from this fountain not in one, but in many jets, which proceeded from flowers arranged in a circle, and from cornucopias supported by four figures at the base. Owing to some defect in the construction, this fountain, which was entire the preceding evening, was found in ruins one morning toward the close of the Exhibition, and it was not restored.

The mineral manufacturers' trophy formed the next object of note in this avenue. It consisted of large polished pillars of Madrepore marble, the veining of which was very beautiful; and also of a carved cross of good design, executed in Caen stone, and of a tablet in Purbeck marble. Beyond these was a very remarkable object, a chancel screen of Gothic design carved in wood. The screen itself, though fine, was less an object of interest than the method by which it had been produced, as it was a specimen of the application of machinery to the art of wood engraving, and so admirably was it executed, as to equal many productions of a similar kind wrought entirely by hand. The same machinery is also capable of carving in stone, and is capable of turning out several exact copies of an original subject at one and the same operation.

A great slab of Honduras mahogany formed another timber trophy, wonderful of its kind in this part of the nave; and was surrounded by crystalline masses of immense size, which formed the trophy of the extent and perfection of chemistry in its application to the arts. The masses of spermaceti, alum, and sulphate of copper, which were here exhibited, were wonderful evidences of the development which has marked the progress of industrial chemistry of late years. Such vast crystals could never have been obtained in any of the processes of the largest laboratory of the scientific chemist. They illustrate the fact that in order to supply the manufacturer with chemicals for the dyeing, printing, and bleaching of his goods, the chemist has himself become a manufacturer on the largest scale, of those chemical substances employed for these or similar uses. No country but England could have exhibited such a spectacle as that presented by the chemical trophy in the western nave of the Great Exhibition.

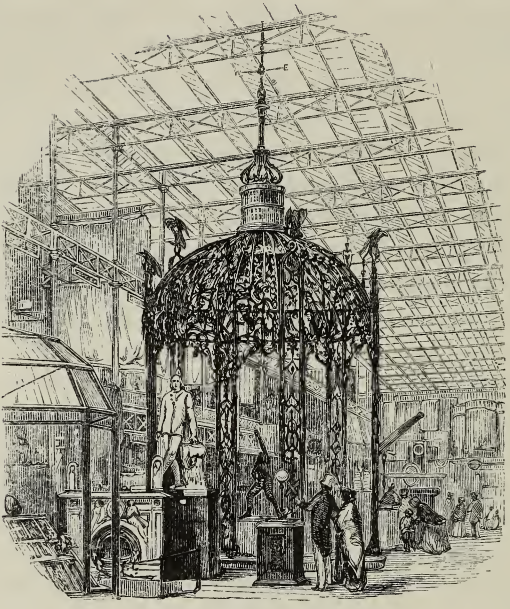
A turret clock of very simple and economical construction, and of good performance as a time-keeper was placed in a conspicuous position in this part of the avenue. The wheels were made entirely of cast-iron, and the bell attached to it was a specimen of a new alloy of metals intended as a substitute for the curious compounds generally used for such purposes. The tones were clear and deep. A full-sized catadi-



LIGHT-HOUSE.

optric apparatus for lighthouses was next in position, and formed the counterpart to a similar one near the termination of the avenue. The glass of both these arrangements was beautifully cut, and reflected the light falling on it from the roof alone with great brilliancy, but the glass in both instances was of a greenish cast, in one much more decidedly so than in the other, which was made of foreign glass. The cut shows this apparatus. Occasionally the lamps in these lighthouses were lighted, and an opportunity was thus afforded for studying the reflection and refraction of the rays of light as they were illustrated by the catadioptric arrangement of the lenses and prisms of glass in these forms of apparatus. The intensity and power of the beam of light emitted was manifest even during the brightest daylight, when ordinary artificial light is scarcely appreciable.

Beyond this was another object not less remarkable, an immense reflecting telescope. The tube of this great equatorial telescope was twenty feet long, and it was fitted with an object-glass of nearly twelve inches in diameter, a size in the construction of which, great mechanical difficulties exist, which have seldom been successfully overcome. This instrument was mounted on a solid stand of cast-iron, and it, with the philosophical apparatus just described, may be regarded as the trophy to science. Another of these typical groups arranged in the vicinity of the preceding, was one of cutlery, which displayed every variety of this kind of Sheffield produce, inclusive of a monstrous knife with an immense number of blades and other instruments attached to it. As a monument of the skill attained in iron-casting was an immense rustic dome in imitation of the trunks and branches of trees, contributed by the Coalbrookdale Company, and represented in the annexed engraving. It was a remarkable example of metal casting, and formed a conspicuous feature of this avenue, being visible, from its altitude, from many parts of the building.



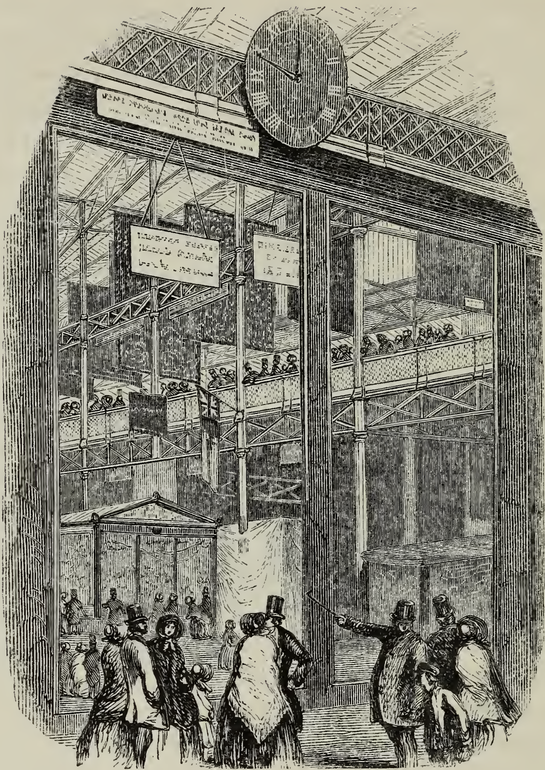
THE IRON DOME.

There was also a trophy of furs and feathers. The fur trophy was beautifully arranged in a glass case, and exhibited some furs which are used only by royal or imperial personages, and were consequently of great value. Many very rare furs from all quarters of the globe were also here displayed. In close proximity was a case containing feathers for ornamental purposes of every species, and of all gradations of tint, some of them being of extreme rarity and value. Beyond these was the trophy to the science of construction and civil engineering in the beautiful models which were placed here. One of these was a model of a suspension-bridge erected over the river Dnieper, at Kieff, in South Russia, designed by Mr. C. Vignolles. A similar model to the one exhibited was made for the Emperor of Russia, and cost upwards of 12,000*l.* The scale was

$\frac{1}{8}$th of an inch; all the details were imitated with such nicety, even in the size of the nails and the threads of the screws, that from it a perfect copy of the original bridge might be executed on a full scale, without any written description. The abutments would take to pieces, to show the construction of the masonry and the chambers for the chains. It contains 6880 pieces of wood, and 87,097 pieces of metal. Before the construction of the suspension-bridge at Kieff, a bridge of boats was in use, the river being 1200 feet wide.

A large fountain in artificial stone, formed another feature of the avenue near its western extremity, and in the same position were placed several models of interest, particularly the Trigonometrical model of the Undercliff, Isle of Wight, in which the topographical features of the part of the balance represented together with its geological structure, were displayed in a manner both exact, and readily appreciable by the eye. Among the westernmost objects of this avenue was the beautiful model of the docks and port of Liverpool on a scale of eight feet to the mile. This model gave the most complete and accurate idea of the important town from which it was sent, and its proportions were sufficiently large to admit of the distinct recognition of streets and even houses. As this avenue was marked almost at its entrance with a trophy in the manufacture of glass, presented by the crystal fountain, so its termination was distinguished by a similar triumph, although in a different direction, in the immense sheets of plate glass which were there placed. Two enormous mirrors, the largest, it was said, in the world, were placed vertically at this point, and side by side they reflected the long avenue and galleries of the building with a degree of brilliancy and effect truly surprising. The position, size, and reflecting properties of these glasses are well shown in the cut.

On ascending to the gallery immediately above this



GIGANTIC MIRRORS.

entrance, the western,—a beautiful view of the whole extent of the building was gained. Here the beautiful regularity of the perpendicular columns, supporting the light and elegant roof, and the diminishing lines of the girders running along the front of the galleries were well seen. The light-house, fountain, trophies of various kinds, the telescope and cast-iron dome were distinctly visible, and in the extreme distance were seen the outspread figure of the eagle and flags supporting it, placed over the United States department. The flags which were hung at right angles with the galleries, were also very distinctly seen from this point. These flags generally represented the arms of the towns or cities contributing to the Exhibition, and were many of them extremely rich and handsome. The general aspect of this avenue formed a remarkable contrast to that of the foreign nave. On the British side were objects related to the industrial arts or to science, and these formed the principal and the most distinguishing features. On the Foreign side, on the contrary, were statues and objects in the fine arts almost exclusively. There was a general air of solidity and character of permanence in the arrangements of the exhibitors in their states and fittings, which offered few points of resemblance to the light and tasteful arrangements of their foreign competitors which were much less costly, and better adapted, as it would seem, to a mere temporary purpose.

It may be convenient to sketch the contents of the side areas and galleries of the building from this point, the gallery over the western entrance. And it will be proper to commence with the ground floor, giving, of course, a mere superficial glance at its contents all the way as far as the transept. The following classes were arranged in this quarter of the building,—classes (1, 9, 12, 14, 15, 18, 22, 26, and 30), or, in other words, it was devoted to the display of raw materials, agricultural implements, woollen and mixed fabrics, and shawls, printed fabrics, flax and linen, general hardware, brass and iron work of all kinds. Locks, grates, and Birmingham and Sheffield goods, furniture and sculpture. The space occupied by these classes extended from the western wall of the building to within a short distance of the transept. As any special objects in these classes will be again brought under notice it may not be here necessary to do more than allude to the position they thus occupied. A most complete idea of the important departments of industry represented by these classes was given by the objects exhibited, and it would have been difficult to instance any important article included by them, of which not only one, but many specimens were not to be found. Near the sculpture court, in which were placed the productions of British artists, was the Mediæval court, in which all kinds of church furniture, as used in the dark ages, were represented, together with some curious attempts to revive arts of metal work long since extinct.

The British colonies and India occupied the space between this point and the transept, on the ground floor. These were the Cape of Good Hope, Africa, parts of Canada, Australia, N. S. Wales, the West Indian Islands, New Zealand, and India. The Indian productions were arranged nearest the transept. They were of a rare and gorgeous, and also of a useful and instructive kind. Rich shawls and brocades were in glass cases, and singular specimens of Indian cutlery, and rude arms, and artillery were also placed there. The collection of raw produce was extremely valuable and extensive, and presented a complete picture of the industrial resources of our dominions in the East. The magnificent jewels, and specimens of working in silver, and of enamelling, which were placed under a glass case at the entrance to this collection from the nave, proved universally attractive. In the interior space was a magnificent howdah and elephant, and the gorgeous magnificence of a tent of state supported by pillars of silver. The musical and other instruments and implements exhibited were very remarkable. The famed textile productions of the Indian loom were also seen here, including some specimens of Dacca muslin of amazing fineness. The Indian products were also exhibited on the other side, the northern, of the nave.

The Canadian contributions were also very complete, valuable and interesting, and developed in a remarkable manner the natural riches of this important colony.

The agriculture of the country was largely represented. The specimens which appeared in this capacity consisted of such articles as barrels of wheat, flour, &c.

The Canadian winter pastime of sleighing was illustrated by the elegant single and double sleighs sent to the Exhibition. Among the manufactures of another kind were specimens of dressed porpoise-skin and whale-skin, employed as a substitute for leather with advantage.

Timber constituting a very prominent feature in the export commerce of the country, the white and red pine, the black walnut, maple, cedar, beech, and butternut, were among the most important varieties. The great futtocks for ship-building, yielded by the tamarisk-tree, were likewise interesting. Among other articles of vegetable origin, was a canoe, made of the bark of the white birch, which was of some interest. This fragile vessel had in safety made a voyage of three thousand miles, carrying a crew of twenty passengers, with their provision and other necessaries.

Among miscellaneous objects, was a piano, manufactured of Canadian woods, specially fitted to endure the changes induced by the vast range of temperature in this country, and also a church bell forwarded from Montreal. A very prominent object exhibited was a handsome fire-engine of great power. The alarming nature of the conflagrations occasionally breaking out in Montreal renders the possession of powerful means of extinguishing them highly necessary. This engine was capable of throwing two streams of water to a height of 160 feet each. A number of native curiosities added to the value of this collection.

Next to the Canadian contributions were those of our West Indian Islands. In giving a condensed view of what was exhibited in these and other instances, it may be permitted to give a summary of the official descriptions written for the larger catalogue of the Exhibition by the author of this work, and forming a complete, but necessarily a very condensed view of every separate collection contained in the Exhibition. Perhaps no part of that work is calculated to be so permanently interesting as that which is intended to show the peculiar commercial and industrial capabilities of each country or colony contributing to the great industrial display.

The contributions of New South Wales, Van Dieman's Land, and South Australia were arranged in one space near each other. About twenty exhibitors from New South Wales sent articles for exhibition. The character of these productions was well calculated to illustrate the peculiar and commercial importance of the colony itself. They consisted principally of raw materials and produce, wool being the most prominent. Australia may be rightly considered the most extensive wool-producing country in the world. The climate combines the qualities essential to a wool-growing district, being dry, with a warm summer and a cold winter. The breed of Merino sheep have proved one of the chief sources of the prosperity of the Australian wool trade, now grown into national importance, and in the past year amounting to 36,000,000 pounds, valued at 2,000,000*l.* sterling. On the estate in which they were first introduced, of which four coloured views were exhibited, an interesting experiment is now being made of introducing the cultivation of the vine. The vineyards are situated on the Nepean River, forty miles south-west of Sydney.

No wines being permitted for exhibition, the specimens sent over were not found in this collection. Australia possesses every requisite in regard of her natural capabilities for producing wine and dried fruits, not inferior to Spain itself. But experience is as yet wanting. The increasing importance of the tallow and leather trades was evident from the contributions of that kind which were shown. A simple apparatus for determining the relative efficiency of different propellers, was also shown. The contributions from Van Dieman's Land were of a very interesting character, and composed an extensive and valuable collection of specimens of woods, applicable for every purpose of art or use. The musk-wood of this colony, as an instance, is valuable for ornamental purposes, of a close and fine grain, and variously veined and dotted. The wood of the myrtle is of a beautiful vein and watered, fitting it admirably for picture-frames. The blue gum-tree appears as a valuable substitute for oak in ship-building, reaching a vast height in the forests of this colony. Two sections were exhibited which were taken at a distance of 135 feet apart, and a small difference in their diameter appeared. The Huon pine is likewise a valuable timber, and specimens of it were exhibited as applied to domestic and ornamental purposes. It was also proposed as an excellent material for organ-pipes, which might be bored out of the solid timber, and some pipes were exhibited. The advantages claimed for them are, that they yield a softer and more mellow tone than pipes made of a looser grain. This wood is also extremely durable, and little influenced by atmospheric vicissitudes.

Vegetable products of various kinds were also exhibited. The agriculture of the colony was represented by various specimens of wheat, barley, flour, &c. Some interesting articles of furniture, formed out of richly-marked woods, were presented to notice, and might direct the attention of decorative furniture makers to the capabilities of the materials for the construction of furniture in England. A few specimens of textile manufactures were also shown, such as a roll of tweed, made of colonial materials. A considerable number of specimens of fur, and of the preparation of leather, harness, &c., indicated that progress in this important manufacture had been made by the colonists. The gum resins of the wonderful liliaceous trees of Tasmania, the grass-trees, were exhibited, and suggested as a material for the dyer and varnish-maker. Specimens of what is called the native bread of Tasmania were also shown. This is in reality a large underground truffle, known botanically as *Mylitta Australis*. One of the specimens weighed originally upwards of fourteen pounds. To these we shall have to return on another occasion.

The furs of those animals which communicate so peculiar a feature to the zoology of Australia generally, the *Marsupials*, were exhibited in a manufactured and unmanufactured state. The feathers and oil of the sooty petrel, with other articles of industrial value, were exhibited. Honey and wax were likewise sent; and it would appear that the culture of the industrious insects producing them can nowhere be more successfully conducted than in this colony.

There was but a small array of articles from South Australia. The specimens presented, were, however, of a very interesting and valuable description. The copper ores, which have been so productive of commercial prosperity to the individuals concerned in their extraction, are shown by an interesting selection from the Lyndoch Valley mines, near Adelaide, and the Burra Burra mines. The extraordinary results of the latter undertaking are among the occasional marvels of mining speculation. Specimens of the carbonate and oxide of copper and of native copper were exhibited. In addition, were specimens, illustrating a recent attempt to introduce the cultivation of the silkworm into this colony. Some agricultural and geological specimens were also interesting.

A valuable and tolerably extensive collection of native and other products was forwarded from New Zealand. Among the raw materials were specimens illustrative of the geology of certain districts. Among these was some copper ore from a small island, distant a few miles from Auckland. To this ore the attention of the miner had already been directed, and a Company had been formed for its extraction. Other specimens from mines differently situated appeared to indicate that extensive supplies may in a short time be obtained from this interesting country. Some blocks of lignite and Waikato coal represented some of the stores of mineral fuel possessed by the country. Sulphur and manganese were also sent. The abundant store of iron contained in the iron-sand of Cooper's Bay, Auckland, has at length been made available for the manufacturer; and the first casting at Auckland Foundry in December 1850, was sent for exhibition: although very inferior to our own castings, its presence indicated an important feature in the future prosperity of the colony. Vegetable produce was also represented by specimens of New Zealand flax, bark, dyes, Kauri gum, orchella, timbers, malt, and hops. The manufactures consisted only of coarse cloth, basket-work, leather, and some native curiosities.

The contributions from British Guiana belonged almost exclusively to the first section of the classification of the Exhibition. There were a few specimens of native manufactures in wood and woven work, as the shaak-shaak, used to make a noise in the dances; the singular baskets used by Indian women to carry their children in, fly-brushes, baskets made of the cabbage palm, fans of the eta palm, &c. But these exhibited that neat but rude and simple industry which, with little or no elaboration of the raw material, produces implements and ornaments from the most convenient substances yielded by nature. The articles in the first four classes were extremely valuable and interesting, not only to the naturalist, but also in a commercial point of view, and these will again come under our notice. The arrow-root, starches, tapioca, coffee, cotton, sugar, and timber abundantly yielded by plants in this prolific colony, were well represented. Several of the contributions were made with a view to learn the probability of the development of a commercial demand for some new articles. The timber of this colony will probably ultimately become valuable in commerce. Several medicinal products were likewise exhibited.

The Trinidad collection was one of much value and interest. It consisted chiefly of a series of natural specimens and productions. The few manufactures exhibited were of native production; they comprised sieves, baskets, fans, and such like articles. There was also a model of an Indian hut, with its simple and primitive furniture. The remarkable phenomenon, the pitch lake of this island was represented by a variety of specimens of pitch; some taken from its centre, some from the shores, and some from the earth in its vicinity. An economical application of this substance in the manufacture of charcoal for sugar had recently been made. Minerals, metalliferous ores, clays, &c., were also sent for exhibition. Tortoise-shell and whale-oil represented the animal kingdom products. Those of the vegetable kingdom were much more numerous. Among these were spices, oils, textile materials, agricultural products, gums and resins, drugs, and woods fitted for useful and for ornamental purposes. To many of these the attention of the naturalist, nor less that of the merchant, might perhaps, as one result of their being exhibited, be directed, and they may ultimately prove of great benefit to the island.

Next in importance were the productions of South and Western Africa, which were arranged at the side of the avenue, and thus attracted, perhaps, more attention than had they been placed with some of the other colonial contributions. The following is a brief summary of these contributions.

The collection from the Cape of Good Hope, added to that forwarded by the Agricultural Society, consisting of a variety of articles from South Africa, was the contribution of about sixty exhibitors. With the exception of a few specimens of furniture, and native manufacture in wood, &c., it was valuable chiefly as illustratory of the raw materials furnished by the districts which it represents. The minerals sent from the Maitland mines, inclusive of lead and iron ores, and also of graphite and coral, were the chief representatives of the class of raw materials. There was also a slab of coloured marble from Natal, mounted as a table on a stand of oak. Specimens of crude and of partially-purified cream of tartar, with some medicinal plants and drugs, were also sent. Several kinds of bark for the use of the tanner, walnut-oil, and oil from the sheep's tail and sea-elephant; some impure carbonate of soda, prepared from incinerated plants, called gunna ashes; specimens of orchilla weed, guano, and honey were likewise interesting. Among the vegetable products the berry wax, obtained probably from a species of *Myrica*, deserved notice. The articles of food consisted of maize, wheat, flour produced in the Cape Colony, preserved fruits and provisions, and dried fruits. The skins of wild animals were exhibited in their unmanufactured state, and also in the form of the karosses worn by the Kaffres. There were also fine specimens of ivory and elephants' teeth, and a large pair of ox-horns, measuring from tip to tip upwards of 8 feet, sent from Port Natal. Specimens of the feathers of the ostrich were also sent in illustration of this important article of colonial export. A tippet made from the feathers of various Cape birds was also exhibited.

New Brunswick supplied a miscellaneous collection of raw and manufactured articles for exhibition. The timber trade was represented by a series of woods; the mineral wealth by some specimens as yet undetermined, and others of iron, and other metalliferous ores, in addition to grindstones and stones for hones. Specimens of coal and plumbago were also sent. The agricultural produce consisted of wheat, barley, oats, beans, &c. There were also specimens of preserved food.

The collection from the Bermudas was extremely small, and consisted only of a few specimens of arrow-root and palmetto plait, and sometimes miscellaneous objects. As arrow-root and the plait of the palmetto-leaf form an important branch of the commerce of those islands, they formed its appropriate representatives.

A most complete collection of wax models was sent from Barbadoes in illustration of tropical flowers, fruits, &c. Among the specimens of natural produce were textile fibres, minerals, and medicinal substances, some of which were new and interesting. The sugar produced in the island was also represented by several specimens produced by different manufacturing processes.

The two last collections to which we think it necessary to make allusion, arranged on the south side of the western avenue were those of Nova Scotia and St. Helena. The mineral wealth of Nova Scotia formed the chief subject of illustration in that collection; and the objects exhibited proved the large extent and importance of the sources of iron of the best kind recently made available in that country. Charcoal iron adapted for the manufacture of steel was here shown. In addition to the metalliferous minerals, several others were exhibited of interest to the geologist and naturalist. A collection of stuffed birds and animals was accompanied by specimens of native manufactures of the usual simple description.

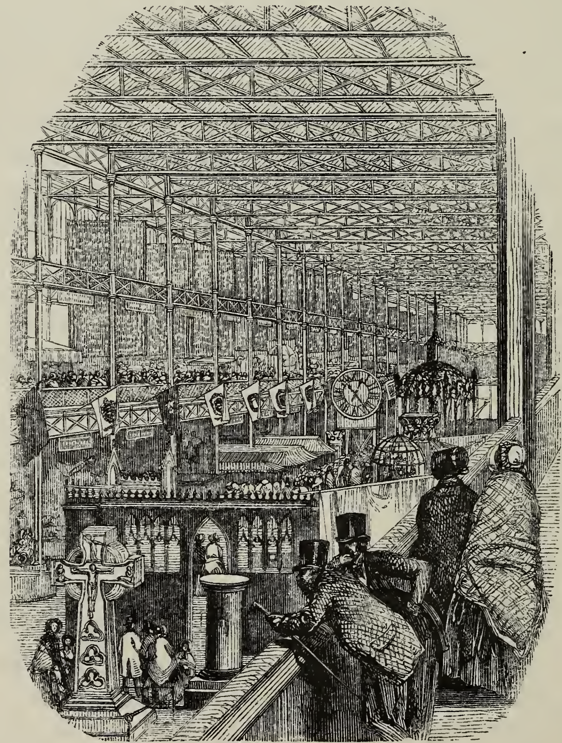
The small but interesting island of St. Helena was represented by four exhibitors, who sent a few specimens of its products to the Exhibition. The Agricultural Society recently established in the island, with a view to promote the cultivation of several plants which may yield a profitable return to the farmer, forwarded specimens of raw cotton, a box of alkali, and some rock salt. Coffee has lately been grown on this island, and a specimen was sent for examination. Much attention was claimed by a few minerals from Longwood, the residence of the late Emperor Napoleon.

As no opportunity of again noticing these collections in their entireness will occur, and as it is extremely important to present a picture of their general features, in a work professing to treat of the industry of nations, we have given some space to their description, not, however, it may be hoped, more than their consequence demanded. It will be necessary, when describing the opposite side of the building, the northern quarter, to mention the contents of one or two other colonies and dependencies. We have thus given a succinct account of the entire contents of the southern quarter of the building on the ground floor.

It may be useful, in adverting to the contents of the galleries of this quarter of the structure, to take the reader again to the point of departure, namely, the gallery over the western entrance doors. Looking from this point eastward towards the transept, were seen clocks, displays of watches (Class 10), a magnificent collection of jewellery and plate (Class 23), lace and embroidery (Class 19), and silks and shawls (Class 13). The estimated value of the plate and jewels exhibited by one of the largest firms in the metropolis, was stated (perhaps a little *over*-stated) at 300,000*l.* sterling; and the amount of silver was estimated by the ton! We have no means of ascertaining the real facts, but if they were taken at one half the amount given, the opulence of these exhibitors may be conceived of. At the side of the building were collections of arms and models (Class 8), of vegetable and animal substances of industrial value (Class 3), of substances used as food (Class 4), and of chemical substances (Class 2).

In the opposite, or northern gallery, observing the same order, were philosophical and musical instruments (Class 10), glass, chandeliers, &c. (Class 24), and china and pottery generally (Class 25). At the side of the building were models and other specimens, illustrating the arts of civil engineering, architecture, &c. (Class 7), cutlery, and, near the transept end, vegetable and animal manufactures (Class 28). At the end from whence this survey is supposed to be taken, was an immense organ, of eighty stops, clocks, globes, and astronomical apparatus.

The arrangement of the carpets in the building was so peculiar as to justify a few remarks. It is repre-



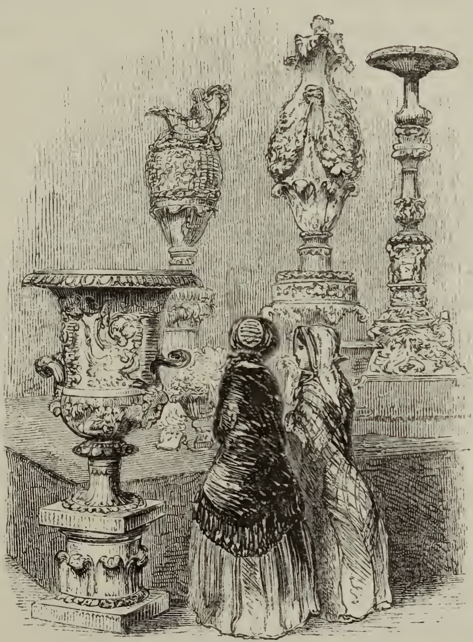
ARRANGEMENT OF CARPETS.

sented in the annexed engraving. They were suspended from the girders overhanging the galleries, and were thus placed in the most favourable position for displaying their excellencies. Some of them were very rich and costly, and, among others, was one exhibited by her Majesty, and assigned for Windsor Castle, and another, the ladies' carpet as it was called, to which allusion has already been made in the account of the opening of the Exhibition. In addition to carpets, were various specimens of floorcloths, which were also suspended in the same manner. The effect of these arrangements upon the transmission of sound in the building, was very marked, the most powerful instruments being scarcely audible from some portions of the structure.

Descending again to the ground floor, the contents of the north western quarter of the building may be sketched in the following order. At the side of the central avenue were cotton fabrics (Class 11), leather, furs, and hair (Class 16), mineral manufactures (Class 27), furniture and decorations (Class 26), paper printing, &c. (Class 17); and, near the transept, the productions of the Channel Islands, Ceylon, Malta, and India. A little to the north of the productions of these former places, was a court, called the Fine Arts court (Class 30), and containing a very miscellaneous collection of objects, including a great sideboard of elaborate carving, cut from the wood of an oak formerly growing at Kenilworth. In other courts adjoining the main avenue, and nearer the western entrance, were arrayed marine engines, not in action, and carriages, both included in Class 5. A long side avenue in this quarter, was occupied with a splendid display of locomotives, some of the narrow guage, and an immense one of the broad guage; all sorts of railway apparatus were here likewise displayed. In a court which was partitioned off, at the north-west angle, was one of the most striking features of the whole Exhibition;—a display of cotton machinery, showing every stage of the preparation of cotton, from the carding-engine to the power-loom. Some American stone-cutting machinery was also placed here. The remaining space in this quarter was occupied, after deducting for the refreshment courts, with a vast display of machinery in motion, of every description, inclusive both of steam-engines, of every form, and manufacturing machines for almost every purpose. It has been already stated that only in this part of the Exhibition Building, were moving objects permitted to be arranged, and these were set in motion by high-pressure steam conveyed in pipes underneath the flooring.

Before completing the survey of the British side of the building, it is necessary to notice the productions of our dependencies, which were placed on the ground floor, in certain areas allotted to them near the transept. The other portion of the Indian collection, on the opposite side, has already been noticed. On this side a very interesting object was the carefully protected glass case, containing jewels of almost fabulous value, the property of the East India Company. Among these was the great diamond, called the sea of light, several very large rubies, and a girdle of emeralds. Many other rare and costly objects were likewise displayed. In a court beyond, was a beautiful tent, decorated in true Eastern magnificence, and glowing with gold embroidery. In it was placed a gorgeous chair of carved ivory, presented to Her Majesty the Queen, which was without a parallel in the whole Exhibition; it was accompanied by a footstool of similar workmanship. An interesting series of native models, and of specimens of native manufactures, was contained in the space beyond it. The figures representing the Hindoos employed in the various arts and manufactures, formed a most instructive and entertaining study. From Ceylon were sent a miscellaneous collection of objects, including some raw materials, vegetable and animal substances used as food. Coffee, cinnamon, tobacco, and sugar, were among the latter class. There were also some interesting specimens of textile materials, and a complete set of models illustrating an improved method of curing coffee, practised in Ceylon.

From Malta was forwarded, by about thirty-four exhibitors, a collection of interesting objects representative of its local manufactures. The only specimens of raw material sent were some pieces of Maltese stone, oiled for pavement, and in their natural state, and some specimens of cotton and silk of native production. In addition to these were a few samples of seeds and wheat. The nankeen cotton cloth of Malta was sent by several exhibitors. Some elaborate specimens of embroidery and of jewellery, and articles in gold and silver filigree, were extremely pleasing. A prominent



CARVED MALTESE VASES.

part in the collection was formed by the stoneworkers, some of which exhibited skilful execution and tasteful design, as may be conceived from the preceding cut.

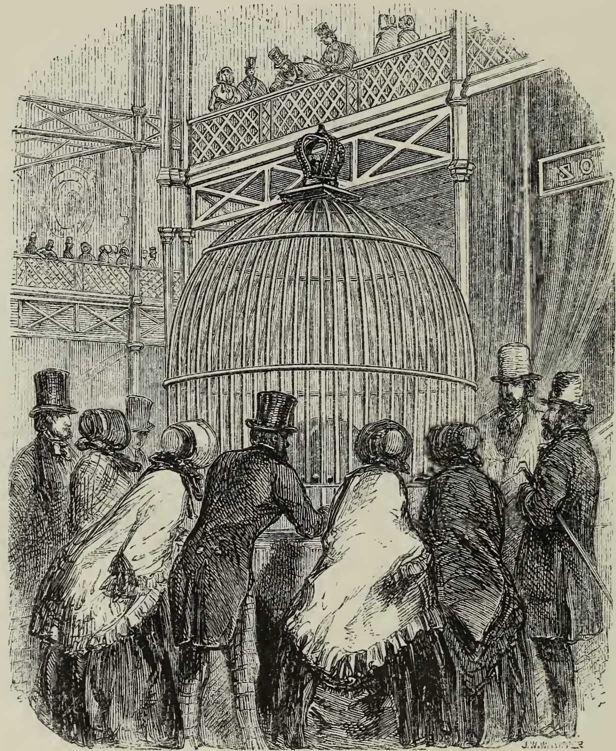
The contributions from the Ionian Islands were very limited, and consisted of articles supplied by certain noble and distinguished persons residing in this country, and interested in those islands. These products were principally articles belonging to the classes of textile and ornamental manufactures. The specimens of embroidery exhibited were extremely rich and beautiful, and formed a characteristic contribution. The filigree work was also exceedingly delicate, illustrating a department of skill in the working of precious metals which has no representative in our own country.

The space occupied by the contributions from Guernsey and Jersey, presented an interesting picture of some of the native productions. A collection of wheats grown in Jersey, and arranged with considerable care; and under the name of manure, "vraic" was shown. It consists of the burnt and fused ashes of marine plants. Specimens of iodine obtained from the vraic were exhibited. Some specimens of silk reared in Guernsey were interesting, as suggesting attention to an important and probably ultimately a profitable direction for the employment of capital. There was also a large carved sideboard of native oak. The geological character of this group, which belongs to the primary rocks exclusively, was indicated by a collection in Class 1, of the granites and other rocks of that series entering into the formation of the island. The natural history of the islands was represented by a collection of specimens of conchology.

We have thus sketched the more important features of the British half of the building, including the ground floor of the transept. In the galleries of the transept, over the south entrance, were arranged articles of hosiery, clothing, &c. (Class 20), and shawls and tartans

(Class 12). In the north transept galleries, were china and pottery (Class 25), perfumery, toys, miscellaneous articles, and wax flowers (Class 29), and, in the corner bay, was suspended a splendid cut-glass chandelier, exhibited by Her Majesty. Other beautiful chandeliers were also suspended from the roof-girders over these galleries. The beautiful palms, contributed by the great palm-growers, Messrs. Loddiges, of Hackney, were seen in great perfection from these galleries.

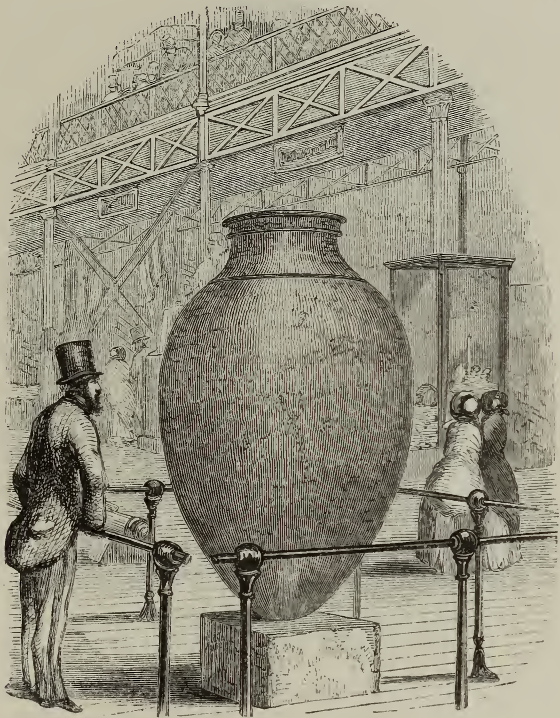
The most difficult task now remains to us,—that of offering a condensed, but accurate view, of the contents of the foreign side of this great building. It will be convenient to observe the same general plan as before, and, in so doing, to give an account of the objects in the central avenue, and, subsequently, of those in the sides, in the galleries, and on the ground floor. The contents of the central avenue do not present much for ornament, being, principally, works of art. The first objects met with were the portraits of the Queen and Prince, beautifully painted in porcelain. Beyond these were two specimens of raw materials, in themselves very interesting; one of these was a magnificent crystal of quartz, exhibited by the Duke of Buccleugh, the other a rich block of silver. Beyond these was the most valuable object in the whole structure, the great diamond, the Koh-i-noor, or mountain of light. It was secured, by an ingenious contrivance, in a strong iron frame. During the day, the diamond was exposed, with its pendants and settings, to public inspection, but, at night, it was withdrawn from view into the interior of a cast-iron frame, so secured that it seemed impossible to remove it thence by force or fraud. The diamond was made to rise, or was depressed, simply by turning a handle, without the interior of the case being touched. This case, and its precious contents, are represented in the annexed cut. On the days of higher admission, it was surrounded with red cloth, and its refractive properties shone by gas-light, but, on the "shilling days," no such expedient was resorted to. The history of this remarkable jewel will again engage



CAGE OF THE KOH-I-NOOR.

our attention on a future page. It was, at one period, a question whether the diamond was really safe in its iron cage, and it was suggested that a mine might have been run underground to the precise spot, and the precious gem stolen away in the night,—an imitation in cut glass being substituted for it. This diamond, and the next object to it, a beautiful shield, called the shield of faith, were exhibited by Her Majesty, and the Prince of Wales, respectively.

A vast jar, which is represented in the adjoining engraving, must be considered as a trophy to the art of the potter, and was, in all respects, an extremely interesting and remarkable object. We shall again refer to

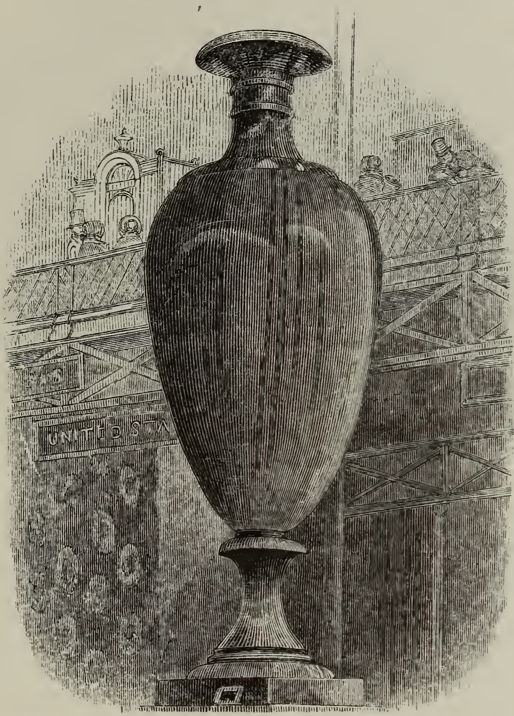


GREAT JAR FROM PORTUGAL.

the uses of this and another somewhat similar vessel; but, it may be remarked, in passing, that such a piece of pottery indicates a degree of facility in dealing with raw materials, and in its manufacture, which, until of late, was not possessed by potters in our own country; and, it may be questioned, whether such a vessel could really be now made at any of our largest potteries. These large jars were employed for the preservation of wine or oil. It would have been easy to put, not one only, but several individuals in it, and it was difficult to look at the great vessel without recalling the fable of the Forty Thieves, who, to their own destruction, were put into jars of this kind. Some large specimens of artillery were near these, and appeared scarcely suitably placed in an exhibition intended to promote peace and goodwill among nations. A beautiful tazza of arragonite, of a golden colour, and veined in a very fine manner, was placed near a large statue of the Queen in zinc, intended to show the capabilities of this metal for such purposes. The statue proved, in itself, far from attractive, and met with more of dispraise than any other object in the avenue. Beyond this was a handsome fountain of cast-iron, of chaste design, and very pleasing appearance, which was kept playing during the greater portion of the Exhibition.

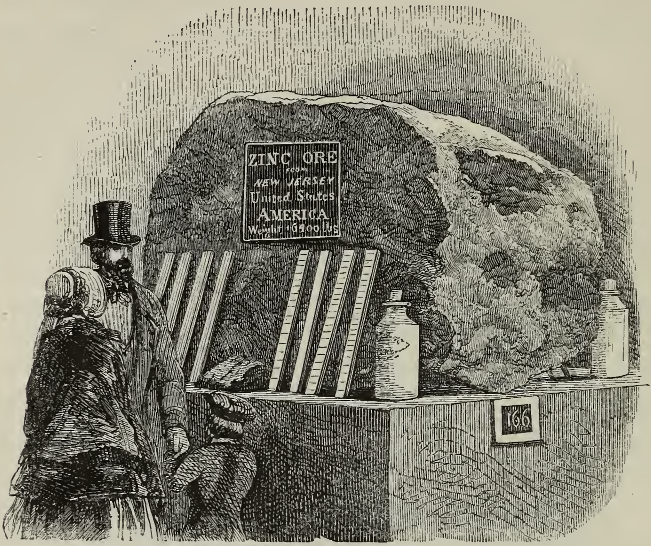
The fine French organ in this avenue often attracted numerous auditors, and its volume and capabilities were repeatedly displayed by a masterly hand. Beyond it were some interesting groups of statuary, several of which were of a colossal magnitude. A large painted window from Milan formed a striking feature of the avenue, and was, in itself, a wonderful evidence of the perfection to which the art of painting on glass has been carried in that city. Few who visited the Exhibition are likely to forget the objects which next succeeded, the Amazon, by Professor Kiss, and the Great Bavarian Lion, in bronze, both of them remarkable specimens of art. The metal-castings from Berlin, generally, were extremely beautiful, and indicated a degree of perfection, in that kind of manufacture, very far beyond any thing as yet attained to in this country. The statue of the Amazon was not bronze, but was cast in zinc, and bronzed over by galvanic deposit, in a very successful and ingenious manner.

The beautiful vase of porphyry, which is represented below, and which was not placed in the Exhibition until near its close, exhibits a wonderful power in the working of the most obdurate materials. There can



GREAT VASE FROM SWEDEN.

scarcely be said to exist any works in this country from which such a magnificent production could have been turned out. The glassy polish of its surface is scarcely represented in the engraving, but it formed a very pleasing character of this great vase. The form of the vase was also simple and grand. Another large object was the production of nature, not of art; it was an immense mass of zinc ore, weighing 16,400 pounds, taken from a vein near the surface, in Sussex county, United States. Its more complete history will be again given. Its appearance is shown in the cut. Some



VAST BLOCK OF ZINC ORE.

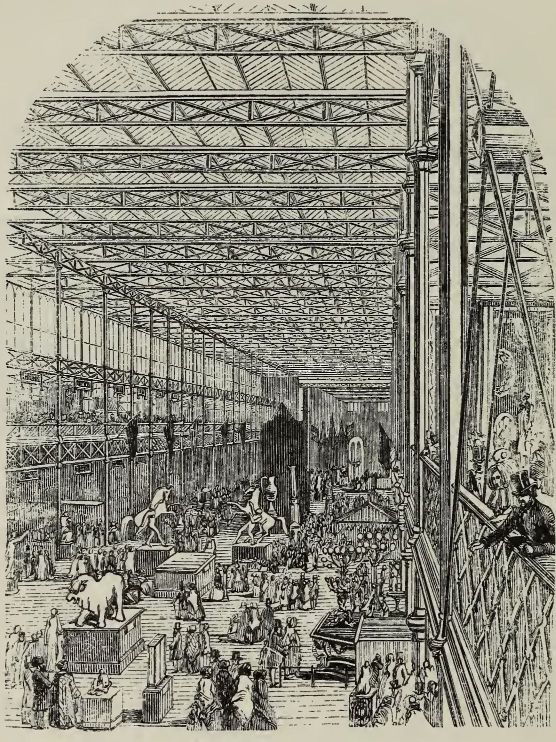
American statuary was beyond this, and a case containing some American newspapers, attracted almost as much interest as many more deserving objects. These were shown as specimens of cheap production. A large bridge, on which was reared what was called an india-rubber trophy, made of india-rubber goods, and a large bell, completed the list of objects contained in this avenue, the more prominent only being regarded.

Ascending to the gallery over the eastern entrance, the same general view of this side of the building, which was taken at the other, may here be given. Looking towards the transept, the productions of the following countries were arranged on the right hand side, ground floor: — United States, Russia, North Germany, Hanse Towns, Zollverein, Austria, Holland, Belgium, France, Italy, Sardinia, Spain, Portugal Madeira, Greece, Persia, Turkey, and Egypt. On the left hand, or southern side, the order was as follows:—

United States, Russia, Sweden, Denmark, Prussia, Saxony, Zollverein, Austria, Belgium, France, Switzerland, China, and Tunis. In the galleries on the right or northern side, were paper-hangings of English manufacturers, United States goods, Russian, Prussian, Zollverein, Austrian, Belgian, and Italian; along the side of this gallery was displayed the stained glass of all nations. It was shown to advantage by darkening the roof, and hanging green baize in front, so as only to admit of light seen through the glass. The left hand, or southern galleries, were occupied by philosophical apparatus, musical instruments, &c., from the Zollverein. Lace and silks, of Austrian production, and the splendid silk display of the manufacturers of Lyons. Near the transept Swiss goods were placed. In the side gallery were British and French articles, and a large array of French printed goods, muslins, &c., very tastefully arranged.

The view presented from the spot, immediately over the eastern entrance, looking westward, is represented from a photograph, in the annexed engraving. The painted window, the statues of the horses from Stuttgard, and the colossal Bavarian Lion, form conspicuous objects, and the general conception of this avenue, as more devoted to the display of works of art than of those of industry, is faithfully conveyed.

It is now necessary to indicate, in a very brief manner, the leading peculiarities of the contributions sent to the Exhibition by different countries, as affording a faithful picture, in many respects, of the present commercial and industrial capabilities of these countries and states. The contributions of the United States were distinguished by their purely utilitarian character, while those of other countries contained specimens of the highest degree of ornament, applied to ordinary objects; the American articles were almost entirely for use, not for show. Many of them were, in fact, of extremely clumsy and rude manufacture. The American machinery was interesting. Great attention was also excited, and a new era in agriculture was, by



THE FOREIGN AVENUE.

some, thought to be introduced by a remarkable reaping-machine. The india-rubber articles were very numerous, and many of them extremely valuable and useful. The American fire-arms also excited great attention. Towards the close of the Exhibition, a large lump of gold ore, from California, was shown, and a breakfast service of pure gold, made from metal obtained from that district. A large collection of natural products, mineral and vegetable, was exhibited. Some remarkably beautiful and transparent glass, totally devoid of colour, was shown. Pianos, carriages, stoves, boots and shoes, and a variety of other objects, were in this collection. One of its very prominent features was the beautiful display of daguerreotypes, which were, without exception, unequalled by any of the numerous examples exhibited.

The Russian collection was distinguished for its costly magnificence. There was, probably, no area in the whole Exhibition so strikingly impressive of grandeur and opulence, as that in which were the malachite doors and vases. These exquisite productions, which were valued at several thousands of pounds sterling, were quite unique, and indicated immense wealth on the part of their producers. Splendid jewels, and articles in gold and silver plate, were also shown, and the colossal candelabra, displayed great perfection in the production of such works of art. There were also some large specimens of porcelain, very finely painted. There were a few philosophical instruments shown, and some machines. The raw materials, especially the iron and copper, were very excellent, and, in some respects, superior to our own. There was a great display also of Russian flax and linen, of fine and coarse qualities, and of leather, in both of which manufactures that country is distinguished for excellence.

Sweden and Norway supplied a small but characteristic collection of objects. The preponderance of exhibitors of iron and other metalliferous ores, sufficiently indicated the direction in which, in these countries, industrial activity is chiefly prosecuted. The specimens of cutlery were good illustrations of the excellence of Swedish manufacture; there was also a large cannon of peculiar construction. The porphyry vase has already been alluded to. Others, of a smaller description, were likewise shown, and also blocks of magnetic iron ore.

Denmark was also represented by only a few—about fifty exhibitors. The articles exhibited included raw produce, machines, manufactures, and fine arts. Among the machinery, was a pump applicable also as a fire-engine, a steam whistle also serving as a water-guage for steam-boilers, a type-composing machine, and a chaffcutting machine. Among philosophical instruments were several clocks and watches, inclusive of an astronomical clock of accurate construction, with a new escapement. There was also some apparatus for philosophical experiments, and several surgical instruments. Several nautical compasses, balanced by a new method, were exhibited; also a specimen of mechanical ingenuity and patience in the form of a file elaborately made, with a number of small files and rasps within it. In the ceramic art two very different classes of objects were shown, but both of equal interest, though of greatly dissimilar value; of these the first were specimens of the black crockery of the Jutland peasantry, made at their own homes, and "glazed" by being smoked so thoroughly as to render them impervious to water. The other were the productions of the Copenhagen Royal Porcelain Manufactory, consisting of vases, figures, &c., in a high style of art. One of the interesting articles in this collection, was an electro-magnetic engine, of new arrangement and considerable working capabilities.

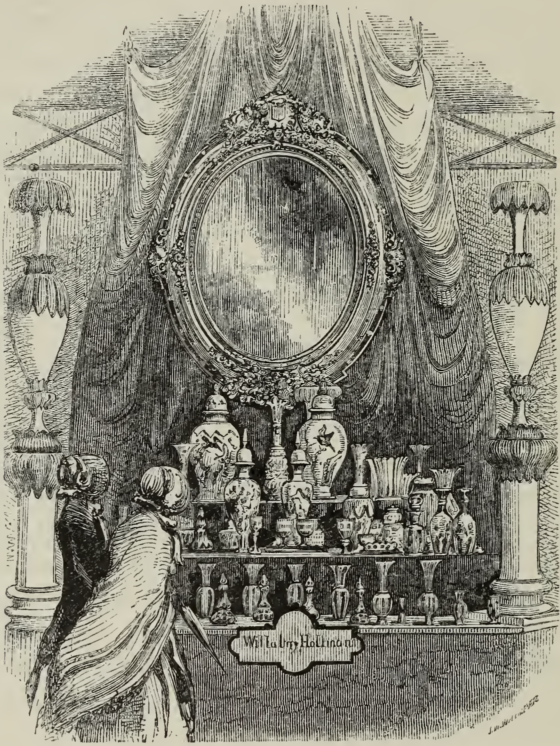
Much curiosity was manifested during the Exhibition to learn the precise nature of the term—the Zollverein. It expresses a confederation of the otherwise independent states of Germany, formed in 1834, for the purposes of promoting international commerce, and promoting a unity of interest among states, the commerce of which was formerly impeded by vexatious and useless restrictions. The following were included under the States of the Zollverein:—

Prussia, Baden, and United States of Northern Germany.—Provinces of Brandenburg, Silesia, Posen, and Pomerania.—Grand Duchy of Baden; Southern parts of the West Provinces of Prussia, and Electoral Hesse.—Provinces of Prussia and Lithuania.—Northern Parts of Electoral Hesse, and of the Prussian West Provinces; Principality of Lippe.—Grand Duchy of Saxony, Prussian Saxony, Brunswick, Anhalt, and States of Thuringia.—Bavaria.—Saxony.—Wurtemburg.—Frankfort-on-the-Maine.—Grand Duchy of Hesse.—Luxemburg.—Nassau.

It may be readily imagined that the contributions of these states formed no inconsiderable part of the foreign exhibition. It is, however, impossible to do more than simply indicate, as in other instances, the general character of the objects sent. In mineral specimens and metal manufactures, the German states were, as may be supposed, extremely well represented, and thus illustrated the extent and importance of that department of industry. German steel, and the valuable ores of which it is formed, cutlery, of very superior descriptions, ores of zinc, lead, and cobalt, were exhibited. There were also a number of exhibitors of chemical productions of different kinds, but these, excepting such as related to the fine arts, as ultramarine, smalts, &c., were very markedly inferior to similar substances produced by British chemists. Among other raw materials of peculiar interest and beauty, were some of the largest specimens of amber probably ever seen in this country. Some of it was in its natural, and some in a manufactured form. There was some large machinery contributed by the Zollverein, and, in particular, a vast vacuum boiling-apparatus, for sugar refiners, stated to be capable of boiling, at one time, a quantity of sugar equal to the formation of two hundred and forty-five loaves, of 30 pounds each. There were also several specimens of implements used in agriculture, differing, in many respects, from our own. Other machinery, of an ingenious description, was sent, but there was nothing of special importance in this class; the German states, however, excelling in the manufacture of objects of art, and in the production of the very finest materials for the use of the tool maker, not being equally distinguished for their mechanical proficiency. The philosophical apparatus was, however, extremely excellent, and greatly superior to the generality of instruments made by our artizans; the chemical and microscopical arrangements were characteristically good and ingenious. In the philosophical apparatus applied to commerce, as in the electric telegraph, the instruments, although clever, were far behind those made in England, in point of execution and finish. In textile manufactures, the cotton productions were not equal to our own, but those of linen were fully so, and, in some respects, superior. Allusion need scarcely be made to the acknowledged excellence and superiority of the laces produced in some of these states. In woollen manufactures the Saxon exhibitors proved formidable rivals to our own producers, and a beautiful display of broad cloths were shown. The specimens of dyed wool, and Berlin wool, were also very superior; there were likewise some fine specimens of wool in the natural state.

It was to be expected that in the production of the finest specimens of porcelain and china, the Zollverein should surpass our own exhibitors, and equal the magnificent productions of Sevres, of the French. Dresden porcelain was exhibited in great perfection. The jewellery also of the Zollverein exhibitors was very remarkable and elegant: some of the specimens exhibited were of immense value, and all indicated great taste. The perfection of the works of art exhibited by these states was extensively illustrated. In order to display these objects in the best manner, a room called the octagon room, a sort of hall, was fitted up, and very tastefully arranged. It contained specimens of porcelain, carved ivory, and cut crystal goblets,—a very favourite kind of ornament among the Germans, jewellery, tables, statues, and a number of minute objects of different kinds. An important feature of the industry of these states is the production of toys! Of these an endless variety was shown, and the number of exhibitors contributing them indicated the importance of a universal demand for the most trifling objects, since a large number are dependent upon their production for their livelihood. Among these the most clever were the stuffed animals from Wurtemburg, which excited universal amusement, and were really remarkable specimens of the art of the taxidermist. The last class of contributions of a characteristic kind to which we shall advert is that of furniture. Perhaps nothing so strongly indicated the foreign nature of the object as a chair or a sofa. The peculiar form adopted, and the passion for ornamenting them with stag's horn, and indeed of forming them out of this material, were quite unlike anything to be seen among the English productions. There were several exhibitors also of japanned wire goods, which also form an important department of continental industry. There existed no feature of distinctive prominence in the contributions of the Hanse Towns, and of the states of North Germany, which is not sufficiently adverted to in the above account of those of the Zollverein. It is not to be forgotten that the statue of the Amazon, and the colossal lion, both remarkable as specimens of metal casting, together with many others of rare perfection, were the production of Zollverein exhibitors, and thus indicated great attainments in the production of such works of art, and in the mechanical processes involved therein.

The Austrian exhibition was very extensive, complete, and remarkable in character. The porcelain and glass articles were large and costly examples of these classes of manufacture, the green and white vases being remarkable for size, elegance, and colour; some of



AUSTRIAN GLASS.

these are shown in the above cut; and the illustrations of painting on porcelain, exquisite examples of art, which has long received the patronage of the government. Paintings on wood, paper, and canvas, for ornamental purposes, were also extensively exhibited.

The most attractive feature was the suite of rooms, the floors being of parqueterie, representing the interior of a palatial residence, consisting of dining-room, library, and bed-room, ante and drawing-room. The furniture and ornaments are alike tasteful and elegant, and the painted ceiling an effective work. The materials used were chiefly of Austrian production. Some of the furniture consisted, however, of beautifully veined locust wood.

A book-case of carved oak, intended as a present to Her Majesty, was a very beautiful specimen of carving.

There was an indifferent mechanical display; but some good philosophical and musical instruments, specimens of printing from the Government printing-offices, oil paintings and printing in oil, so closely resembling each other as to be with difficulty distinguished, were also shown in great variety.

The sculpture-room was likewise a very interesting spot, and contained many beautiful works of art in marble and in plaster.

A very large and miscellaneous collection was also exhibited, including specimens of coloured cottons, woollens, and blankets; pipes and pipe-stems in infinite variety; gloves; musical clocks; walking-sticks, riding-whips, stands of toys, ladies' parasols, &c. There were also various raw products and chemical substances; but these were inferior to our own. The stained-glass window from Milan has already been adverted to.

Belgium appeared in considerable strength at this Exhibition, and the display made was such as to give our countrymen a higher opinion than they are commonly apt to form of the mechanical proficiency of foreigners. The most distinguishing feature of this display was without doubt the splendid and powerful machinery exhibited. There was a large sugar-refining apparatus, of remarkable interest. There was also an expansive and condensing steam-engine of 140-horse power, intended to have wheels with moveable paddles, for the navigation of shallow rivers with strong currents. A locomotive engine with articulated fore-wheels, diameter of piston 16 inches, stroke of ditto, 24 inches for heavy trains running on curves of a small radius. A high-pressure steam-engine of 16-horse power, with vertical cylinder. A high-pressure steam-engine of 3-horse power, with tubular boiler, for agricultural purposes. A model of a Fahrkunst, a German name of a machine for lowering and lifting miners in a coal-pit without danger or fatigue; and many other machines, and implements of use in agriculture and horticulture. Some of the latter were interesting from the known advancement of Belgian agriculture. The raw materials in illustration of agriculture were very largely contributed, and were of fine qualities. The specimens of flax in particular exhibited a decided superiority over those of many other countries. The flax of the Courtrai district in Belgium, is universally acknowledged to be of finer quality than any other sent into the market. The display of Brussels lace was extremely fine, and showed to how large an extent this manufacture has been carried. There were also some Brussels carpets, and other specimens of the Belgian loom. The weapons of warfare exhibited by the Belgians were well made, and included an enormous shell. To the eyes of English Protestants it was a painful sight to behold a heap of Roman Catholic books, missals, breviaries, &c., arranged as a trophy; and the figure of a virgin and child was offensive. The robes of the Roman Catholic dignitaries were displayed upon life-size figures, and gleamed with gold, jewels, and scarlet attire.

Holland was but indifferently represented at the Exhibition as regards numbers. There was, however, a good series of raw and manufactured products. Some very fine candelabra were shown, and considered superior works; and nearly every variety of manufacture belonging to this industrious people: — metallurgy, metal manufacture, woven fabrics, basket-work, clocks and toys, with numerous other articles, formed the interesting features of this section. A small percussion-cap-making machine, producing them from the ribbon-copper, and a sugar-crushing machine, were interesting as examples of machinery.

The collection was chiefly wanting in extent, being very perfect of its kind. In addition to the objects named, were some splendid specimens of jewellery placed in this section by two English gentlemen. Of these one was a jewelled hawk, of the size of the living bird; both the hawk itself, and the rock-work on which it stood, being completely covered with fine gems of various descriptions—rubies, carbuncles, turquoises, amethysts, &c. To this interesting object, there was a legend attached. It was made to commemorate the reconciliation of two noble Dutch families, many years back, who were before at fierce enmity. Within the bird (to be seen on removing the head) was contained the gold drinking cup from which the rival counts pledged each other at their reconciliation. The other jewellery must be again referred to as exhibiting some of the most remarkable specimens of natural productions of this class; it consisted of pearls, beryls, sapphires, &c., of immense value.

The next, and perhaps the most important part of the foreign exhibition, was the splendid display made by France, which occupied a considerable space on both sides of the eastern main avenue, and was in every respect worthy of the great nation contributing it. The following is the substance of a brief survey by the present writer of this collection of industrial objects prepared from official sources.

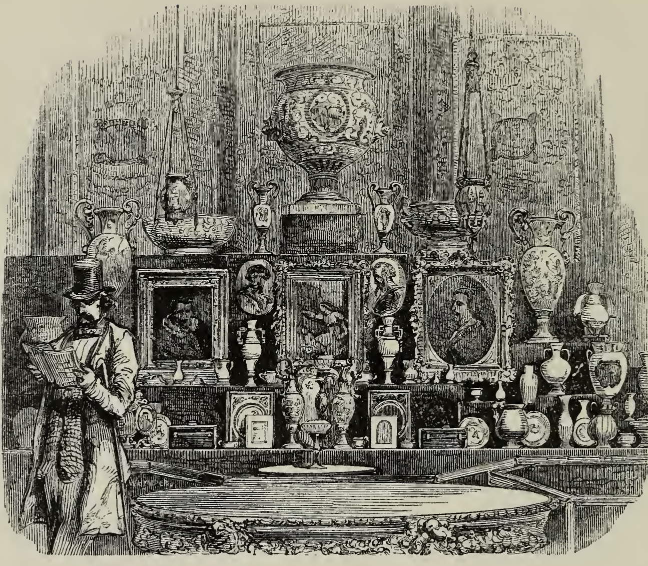
"No class of the Exhibition, considered in its philosophical subdivision, was left unrepresented by the French exhibitors. In raw materials, machinery, manufactures, and fine arts—the four grand sections into which the thirty classes resolve themselves—specimens of every variety were exhibited. The total number of exhibitors amounted to about one thousand seven hundred and fifty.

"Among the raw materials, the beautiful specimens of raw and thrown silk attracted universal admiration. The samples of silk wound by modifications of the customary processes were of great beauty; and an interesting specimen of cocoons in the frames in which the silkworms are reared and permitted to spin the wonderful envelope of the pupa, gave a good idea of the manner in which the culture of these insects is carried on. The hemp, wool, and other textile materials exhibited were likewise interesting. The successful application of philosophy to manufacturing chemistry for a considerable time has produced good results in this department of industry. It is an universally admitted fact that, for some of the more delicate chemical preparations, such as vegetable alkaloids, the productions of the French manufacturer excel those of other nations. The grosser products were likewise exhibited: in these, however, the same success was not so manifest as in similar productions of British exhibitors, probably because the latter are generally manufactured on a very extensive scale. The cements and various specimens of paints exhibited had also their special value and interest. Specimens of metals and of skill in metallic manipulation were also shown,—in particular, some large specimens of beaten copper and rolled brass, and specimens illustrative of the iron manufactures. Articles of prepared food were also largely exhibited, and indicated a branch of French industry of great prominence and importance.

"A good collection of machinery was likewise shown. It included among many objects of interest, a large prime mover in the form of a Turbine water-wheel, a mechanical contrivance for the development of power from the descent of water, of recent introduction, and already of extensive application to the cotton and silk factories of France, and to other mills. The power developed by the fluid in motion is very great, and the arrangement of the machine was extremely compact and effective. The mules for cotton-spinning, the carding engines for cotton and wool, and the endless paper-making machines, formed objects of instructive comparison with the display of similar machines in the British collection. The kitchen apparatus, boilers, and numerous other machines were likewise of an instructive character. The philosophical instruments and musical instruments, inclusive of the organ in the nave, formed also an interesting group of objects. Optical instruments of different kinds were exhibited in great perfection; in these the French opticians greatly excel our own masters.

"Among the manufactures, the gorgeous productions of the silk-looms of Lyons, which were arranged in cases in the gallery, were a wonderful exhibition in themselves. The cotton manufactures, and those of wool and linen, were scarcely less interesting. The skilful arrangement of many of these articles added much to their attractiveness in the Exhibition. The splendid tapestries of the Gobelins, and of other national manufactories, as that at Beauvais, formed perhaps one of the most interesting features of the whole collection. They were accompanied by specimens also of Sèvres porcelain, exhibited in the annexed engraving, the articles in which, inclusive of vases, paintings, &c., were of great rarity and costliness. A fine group of these is shown exactly as it appeared in the Exhibition in the annexed cut. The furniture exhibited partook of the usual character of the French productions of this class, and many indicated the employment of talent of a high order in their design and execution.

"This collection was extremely rich in those articles



SÈVRES PORCELAIN.

which form so large and important a feature in Parisian industry—articles of bijouterie, virtu, &c., and jewellery. The multitude of objects exhibited in this class, and their variety, strongly suggested the idea of a great demand for such elegancies, and of the existence of many skilful designers occupied in their production. The beautiful display of jewels exhibited by Her Majesty the Queen of Spain, and the jeweller of that court, attracted universal notice. The specimens of paper and printing exhibited, included a number of objects of interest; and the coloured and other lithographs, and stereotypes by new processes, evidenced progress in this department. Photographs on paper and on silver (Talbotype and Daguerreotype) were exhibited, and formed a very interesting collection. The French photographers had evidently made great progress in the art of the Talbotype (an English discovery), and beautiful pictures taken by modifications of that process were shown. Those taken on glass plates, of which the positive pictures or proofs only are shown were, in some instances, taken by a process largely employed to obtain photographs for the Royal Commissioners in illustration of the Juries' reports. Objects of sculpture and of the fine arts were likewise exhibited, and added to the interest of the collection."

Such is a rapid and imperfect sketch of this immense collection—the general features of which only could be noticed. The following are the concluding remarks of the notice referred to. "The excellence and abundance of the objects of minute art would appear to indicate a high state of refinement; but their perfection forms, however, an observable contrast to the state of articles of a more ordinary character, and extensive demand. Although much has been done in the improvement of these articles, they do not admit of comparison with the perfect execution and manufacturing skill displayed in those of a more costly description."

The very opposite is the industrial characteristic of the British people; and if a choice must be made it is to be confessed that the state of that nation is best which produces the best things for its general population, rather than that which produces its costly works for a select and opulent minority.

The contributions of Spain and Portugal were very interesting, though in some respects limited in extent. It is deserving of notice that these fine and fertile countries, in which, under the influence of a prolonged system of religious and mental thraldom, commercial activity has itself become paralyzed, were best represented, not by the productions of their inhabitants, but by those of the soil. There was a fine collection of minerals, which in a striking manner revealed the immense metallic riches of Spain. There were also some good specimens of vegetable products. The characteristic manufacture of Toledo, was well exhibited in the swords, one of which was so elastic as to permit of its being bent into the form of a serpent without the least injury. A costly emblem of that idolatrous and superstitious system which has arrested the progress of these countries was exhibited, being valued at 28,000*l.*—it was a piece of altar furniture, and offered a strange contrast to the miserable display of manufactures and industrial articles.

Italy and Sardinia were also largely represented by raw materials and products. The velvets of Genoa and Turin were very beautiful, and some of the articles of furniture were very elaborate in design and execution. The most remarkable and distinguishing feature of the collection was the inlaid mosaic work, of which specimens of extraordinary perfection and finish were exhibited. There was some interesting statuary. The chemical products from Sardinia were extremely good, and carefully prepared. The works in silver filigree were also extremely delicately executed.

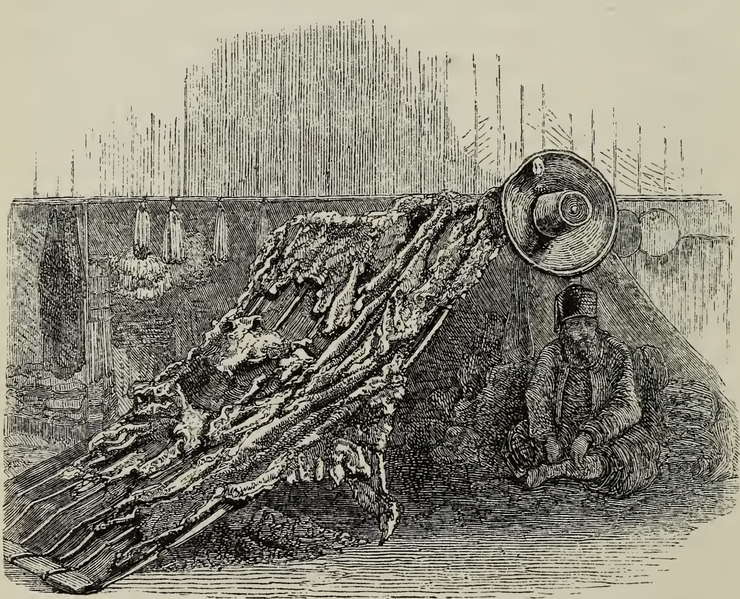
Switzerland contributed a very excellent series of manufactured articles, but no raw products of any moment, with the exception of some iron ores and steel. The characteristic features of this collection, were the muslins and embroidery, the cotton prints, and the watches, &c., exhibited. Those who are familiar with the production of textile fabrics, and the varieties of ornament applied to them, considered the display of these articles as very remarkable, and well representative of the extensive branch of national industry occupied in their production. The cotton prints were also good competitors to our own, and some displayed the beautiful dye called Turkey red, with a degree of brilliance not often equalled, and attributed to the pellucid waters from which the dye-works obtain their supply. The display of watches was very attractive, and curiosities of every description of minute mechanism were shown; such as a watch in a pencil-case, the smallest watch ever made, a minute pistol which required a microscope for its examination, and such like. Instruments of precision were also shown, and various new improvements in the arrangement of watchwork. The straw-plait exhibited, likewise illustrated an important department of peasant industry. There were also some exquisite specimens of wood carving.

The Chinese would not themselves contribute to the Exhibition; but their national industry was represented by the efforts made by certain of our own countrymen. The raw materials included substances employed in the manufacture of porcelain at the Great Porcelain Works in the vicinity of the Poyang Lake. The animal and vegetable materials employed in native and European manufactures, as hemp, cotton, silk, &c., were also exhibited. There were also some chemical preparations, as arsenic, sulphate of iron. Among the articles used as food the varieties of tea were extremely interesting. The means of colouring teas were represented by a bottle of the materials employed. The edible birds' nests were very fully shown. Those characteristic productions of China, the great porcelain vases, jars, and other vessels of this material, were illustrated by some fine specimens. The lanterns, screens, elaborate carvings of every description, the lacquered and japan ware, paintings, and other articles, which had long been known to our merchants, and which recent commercial intercourse has brought to our doors, completed the industrial picture of this empire.

From the Society Islands were sent a few articles by Queen Pomare, forming an interesting collection of specimens of native manufactures. The material of some of these was derived from the leaves of a species of *Pandanus*, that of others was obtained from a species of *Tacca,* and white cloth from the inner part of the bread-fruit tree, with fringe from that of a kind of *Hibiscus,* were also shown. An interesting object also was an Indian vase, employed for keeping the utensils used at meals. Specimens of coffee and cotton of native growth were likewise exhibited in this collection.

New Granada supplied emeralds, and a bag of cocoa. Mexico, wax flowers, a collection of woods, and some description of wax. Brazil, flowers of feathers, a set of native reins, and some ornaments; and St. Domingo a collection of raw material, forwarded by Sir R. Schomburgh.

The collection from Tunis well illustrated the industry of the East. It abounded in costly dresses broidered with gold and silver, and of great value, saddles of velvet covered with gold lace, and beautiful scents and essences—all these were only fit for royal



ARAB TENT.

persons. But the implements of the poor peasantry carried the spectator back to the ages of the darkest barbarism. The examples of iron manufacture and of earthenware, were centuries behind other countries. The tent of horsehair which is represented in the annexed engraving, covered with the skins of animals, represented the true form and disposition of the Arab tent, as it has existed for ages, and as such formed a very interesting object. There was likewise a good collection of raw materials illustrative of the capabilities of the country.

Turkey exhibited the same contrast of barbaric magnificence in those objects intended for the use of the great and powerful, with a miserable display of such as are calculated for the poor, or humble classes. The specimens of embroidery, the carpets, velvets, &c., were rich and costly in the extreme; the specimens of pipes, brass, stones, and vessels for water, and similar objects were also good—but only producible at a price far beyond the reach of the middle classes; while such things as were destined for general utility were as rude, clumsy, and inefficient as the others were costly and magnificent. The raw products were as complete and interesting as any collection exhibited, and a council medal was awarded for them. An interesting object was a clock made by a self-taught Dervish.

Greece was chiefly represented by her raw products. The vegetable products shown included valonia, madder, currants, raisins, tobacco, &c. A jar of Hymettian honey was also shown. The minerals exhibited were chiefly the ornamental marbles, white and coloured, and appear as the raw material wrought by ancient art into those monuments of skill which have formed the admiration of every time and people. The cultivation of the silk-worm is extending in Greece, and specimens of raw and manufactured silk were sent for exhibition.

Specimens of gold embroidery, and some sculptures, were likewise shown.

Egypt, once the renowned of all nations, made but an insignificant display on this occasion, her former dignity and industrial position being remembered. There were, however, a variety of natural productions, both mineral and vegetable, and some skins and ivory. In manufactured articles the most interesting were the cotton cloths, cambric, and silks; much of the latter plaited and embroidered with gold, was of a very handsome description. There were also coffee services in silver, and some other articles in metal. Drugs, seeds, and grains were also shown; with mineral products, saddles for dromedaries and horses, head-dresses in gold and velvet, pipes, coffee-sets, dried fruit, &c. It was evident that all the glory of this country had departed, and that a feeble race occupied the position once held by the most mighty, wise and industrious population of the globe.

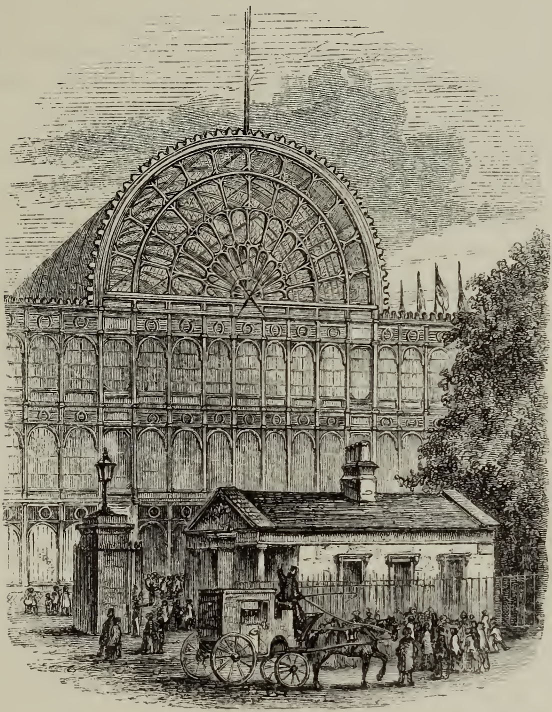
Persia was represented by only one native exhibitor, and by the contributions of a few gentlemen of this country. The articles exhibited were of the usual Oriental type, embroideries, silks, rugs, carpets, &c., and a display of water-pipes for smoking of tobacco, and a few paintings of a rude character. The rugs and carpets may be taken as a sign of industrial energy and activity of some importance; but the other objects are of little moment in this respect.

We have thus endeavoured to fulfil the intention of this chapter in giving a series of sketches of the industrial contributions of different countries, and of our own at the Great Exhibition. It were a difficult and indeed an invidious task to draw a more close comparison than has already been made between the contributions of different nations, and those of this great country. Yet it may be gratefully acknowledged—remembering from whose hand the blessing on our labours has proceeded, that, taken as a whole, the productions of British exhibitors indicate not only a vastly more extended, but also an immensely more advanced condition of industrial attainment than those of any other country. In the higher departments of art we may be behind other countries; but in all that really constitutes national greatness and prosperity, the comparison was very greatly in favour of England. Her machinery, her textile productions for the use of the people, and all those manufactures which relate to the ordinary wants of the social economy, were allowed by many of the contributors from foreign lands to be without a parallel in the Exhibition. We may therefore be well content to be surpassed in objects of art if we surpass in those of utility. True national greatness is not allied to the fine arts, but to those which minister to universal wants; and it may be the legitimate boast of this people, that their manufacturers, rather than their sculptors and artists, are those who really represented the industrial greatness of this kingdom.

The following extract from a speech delivered by His Royal Highness Prince Albert will form an appropriate conclusion to the chapter. "Man is approaching a more complete fulfilment of that great mission which he has to perform in this world. His reason being created after the image of God, he has to use it to discover the laws by which the Almighty governs his creation, and, by making these laws his standard of action, to conquer nature to his use—himself a divine instrument. Science discovers these laws of power, motion, and transformation: industry applies them to the raw matter, which the earth yields us in abundance, but which becomes valuable only by knowledge: art teaches us the immutable laws of beauty and symmetry, and gives to our productions forms in accordance with them. Gentlemen,—The

Exhibition of 1851 is to give us a true test and a living picture of the point of development at which the whole of mankind has arrived in this great task, and a new starting point from which all nations will be able to direct their further exertions. I confidently hope the first impression which the view of this vast collection will produce upon the spectator will be that of deep thankfulness to the Almighty for the blessings which He has bestowed upon us already here below; and the second, the conviction that they can only be realized in proportion to the help which we are prepared to render to each other — therefore, only by peace, love, and ready assistance, not only between individuals, but between the nations of the earth."

CHAPTER X.



GENERAL HISTORY OF THE EXHIBITION.*

We have been led to dwell so much on the constructive history of the Exhibition building, and on its internal arrangements and contents, as to have left little space at this part of our work for a general his-

* The cut represents the south or principal entrance, at the transept, to the Building.

tory of the events attendant upon the Exhibition itself from first to last. The imposing and indeed national ceremony which attended the opening on the 1st of May, has been sufficiently described, and we propose in the present chapter to carry the reader through the short but eventful era which intervened between this period and that of its close, which it will also be our duty in brief terms to describe. It may be worth while adverting, for a few moments, to the state of public anticipation which preceded this event. Probably no event in history has ever been felt so extensively, or created so much curiosity and interest not only among the civilized nations of Europe, but among all classes in the remotest extremities of the world. The reputation of the vast display was as much the topic of conversation in India or in America as at home: and no event has ever occurred which has produced a movement so extensive as this. The most wild expectations were raised. The following though a playful is scarcely an exaggerated picture of the state of mind publicly felt prior to the 1st of May.

"The Exhibition and its promises are the invariable topics of conversation in every suburban omnibus, enter it when you may; tavern-keepers are making eager bargains with their next-door neighbours for the occupation of their houses; doors are being punched through the walls of one tenement to connect it with the next; painters and carpenters are busy in every direction; the paving authorities are looking to the roads; and on all hands an unaccountable, unlimited harvest of gold is expected. Bakers expect to sell bread by the cart-load; butchers think that it will be unnecessary to part the leg from the body of the bullock; grocers believe that it will be superfluous trouble to break up their sugar-loaves; brewers hold it to be impossible to brew sufficient beer to supply the impending demand; and in the goose feathers of an attic bed imaginative lodging-house-keepers look to find the fabled eggs of gold. In the provinces, workmen are in a high state of excitement; while tradespeople, on the contrary, dread a diminished balance in their books as the inevitable result of this vast national movement toward the metropolis. In Liverpool the policy of recommending every traveller to London to start from home with his week's provisions in a basket, as an act of justice to his trading neighbours, has been freely talked of; but is not likely to be carried out. The activity on the part of agents for securing lodgings is very great; and in all quarters lodgings are being caught up, not at exorbitant, but at sufficiently high prices."

The result, however disappointing to those who had without sufficient data elevated their anticipations beyond all reasonable bounds, was nevertheless very considerable, and it may be necessary a little further on to show in how remarkable a manner an influx and efflux of several millions of persons has taken place into the metropolis without producing the inconveniences foreshadowed by imaginative persons.

The general arrangements for the admission of visitors to the Exhibition may here deserve a place. On this subject, as upon others, the most exaggerated opinions were entertained, and not a few persons thought it probable that the lowest term for admission on the first day would not be less than eight or ten guineas. These wrongly conceived notions may be in a great measure ascribed to the entire novelty of the event, which consequently—appearing without a precedent—afforded no elements for sober calculation. In one respect the expectations of the most enthusiastic were exceeded by the fact, for few persons really believed that some six millions of human beings could or would in five months have entered a single edifice, whatever its attractions; or that they could have done so without the smallest symptom of disturbance or insubordination. The following is an extract from the minutes of meeting of the Royal Commissioners, at which the regulations for admission were decided. The attention of the Commissioners had been directed chiefly to the following points.

"1st. The necessity of making such arrangements as shall secure the convenience of the public visiting the Exhibition, whether for study and instruction, or for the more general purposes of curiosity and amusement. 2nd. The due protection and security of the property deposited in the building. 3rd. The effective control over the number of visitors, while the servants and officers entrusted with the maintenance of order and regularity in the building are comparatively inexperienced in their duties. 4th. The necessity of maintaining the self-supporting character of the Exhibition, and of defraying the liabilities incurred. 5th. The desire of the Commissioners to render the Exhibition accessible to all persons at the lowest possible charge, and with the least delay which a due regard to the preceding considerations will admit.

"Having these objects in view, Her Majesty's Commissioners have determined to adopt the following regulations:—

"The Exhibition will be open every day (Sundays excepted).

"The charges for admission will be as follows:—

Season tickets for a gentleman .	£3	3	0
Season tickets for a lady . .	2	2	0

"These tickets are not transferable; but they will entitle the owner to admission on all occasions on which the Exhibition is open to the public.

"The Commissioners reserve to themselves the power of raising the price of the season tickets when the first issue is exhausted, should circumstances render it advisable. On the first day of exhibition season tickets will only be available; and no money will be received at the doors of entrance on that day.

On the second and third days the price of admission on entrance will be (each day)	£1	0	0
On the fourth day of exhibition .	0	5	0
To be reduced on the twenty-second day to	0	1	0

"From the twenty-second day the prices of admission will be as follows:—

On Mondays, Tuesdays, Wednesdays, and Thursdays in each week . .	1*s*. 0*d*.
On Fridays	2*s*. 6*d*.
On Saturdays	5*s*. 0*d*.

"No change will be given at the doors. This regulation is necessary to prevent the inconvenience and confusion which would arise from interruption or delay at the entrances. Should experience in the progress of the Exhibition render any alteration in these arrangements necessary, the Commissioners reserve to themselves the power of making such modifications as may appear desirable, of which due and timely notice, however, will be given to the public. At the first opening of the Exhibition, the hours of admission were fixed from 10 A.M. till 6 P.M.;" afterwards they were altered to from nine to sunset, which was announced by the ringing of the large bells which were placed in different parts of the building.

The events of the first few days of the Exhibition were of little importance, with the exception of those of the 1st of May. The building was in a very incomplete state as regarded the foreign side, and many compartments were absolutely empty, or filled only with packing-cases. The attendance on these days was about fifteen thousand daily. When the price of admission fell the numbers increased with remarkable steadiness. The last two days at that price, Friday and Saturday, May 23rd and 24th, the building was a scene of the most animated kind, and the roads leading to it were in every direction crowded with vehicles containing visitors anxious to see the Exhibition prior to the "first shilling day." On the Friday the receipts reached the sum of £4,095 10*s.* and on the Saturday the extraordinary amount of £5,078. A strong feeling existed that after this period there would be little opportunity of seeing the wonderful contents of the building with any degree of satisfaction, and the result showed that this was only another of the many expectations formed in connection with this undertaking which was not destined to a speedy realization.

It is certain that the first day on which the admission was to be reduced to one shilling was regarded with no common degree of apprehension not only by the public, but by the authorities generally. Barriers were erected so as to prevent any sudden rush, and rules were laid down which were intended to govern the admission and circulation of visitors in the building. Large cards were placed in the different avenues on which an arrow indicated the course to be taken with the addition of the words "That way." Visitors on that day were all to proceed to inspect the building by constantly turning to the left hand, so as to produce a continuous current in a uniform direction. In order to obviate excessive crowding large placards were printed which were to be posted in various parts of the edifice, and contained the announcement "THE EXHIBITION IS NOW FULL." A signal was to be made at Hyde Park which would be recognized in Piccadilly, and approaching crowds might thus be saved the disappointment of closed doors. A strong body of police were in special requisition, and every possible precaution was taken to prevent disturbance or danger from the arrival of the expected multitudes. In what manner this eventful day, May 26, 1851, passed over may best be told by an extract from the *Times* newspaper of the following morning, which we here subjoin.

"Yesterday, to the astonishment of almost everybody, notwithstanding the fall of price to one shilling, the interior of the Crystal Palace was not so much crowded as usual. A great crush was anticipated, and the consequence was that a comparatively small number came. Up to five o'clock only 21,258 persons entered the building, and the receipts at the doors fell to 920*l.* This, with the sale of season tickets, made a total of 960*l.*—an immense decline from the amount collected on Saturday. The visitors appeared chiefly to belong to the middle class of society, and few fustian jackets were observed among them. They did not confine themselves to the nave, but were well spread over the interior, and all seemed intent on making good use of their time, and studying carefully the departments which most interested them. By a judicious arrangement, the seats which had previously been distributed in the nave and transept were removed to the more retired and less attractive parts. It is not now probable that there will be any very great rush of people to Hyde Park till the 1st of June, when the summer excursion trains begin to run."

That this day went thus quietly by was of great advantage to the arrangements of the Exhibition, and to its future success. It was now thought that on the great popular holiday, Whit Monday, the expected crowds of unmanageable numbers would present themselves, and that for once at least the masses would prove too much for the gigantic dimensions of this building. Again provision was made in anticipation, and again the result showed that all was unnecessary. At nine o'clock dense columns of vehicles crowded all the thoroughfares leading to Hyde Park. "Between the hours of 10 and 11 o'clock 21,526 persons were admitted, and appearances promised a day of unusual bustle and excitement. From one of the galleries of the transept the commissioner of police, might have been observed watching with anxiety the seemingly inexhaustible tide of restless humanity poured into the interior. The task of counting so enormous an influx became one of great difficulty, and already an assemblage unprecedented in number was anticipated. Rain began to fall, and all the indications of a damp disagreeable day were realized. Along the approaches to the building bands of sturdy pedestrians might, nevertheless, have been seen pressing forward, sometimes seeking shelter and then starting afresh. Another hour passed away, and it became evident that the rush of visitors was checked. From 11 to 12 o'clock the numbers admitted fell to 12,785, from 12 to 1 they were 8,064, from 1 to 2 o'clock 4,832, from 2 to 3 o'clock 3,312, from 3 to 4 o'clock 1,666, and the total according to the police returns up to the hour of closing was 54,194. At the doors 2,436*l.* 4*s.* was taken."

Thus again the strongest probabilities were defeated, and a fresh incident proved the general ignorance which as yet prevailed on the subject of the movements of great masses under the influence of any subject of popular interest. From this period the daily attendance of visitors at the Exhibition ceased to have any special interest, beyond the fact that thousands day by day presented themselves in numbers still undiminished and apparently unlikely to be lessened. By the end of May 734,000 people and upwards had visited it. At the end of June the sum had increased to 1,800,000, by the end of July to nearly 3,000,000, and by the end of September to upwards of 5,200,000. The total number up to Saturday, October 11th, 1851, was 6,063,986. To which may be added about 100,000 for the exhibitors' days, October 13th and 14th. The smallest number after the commencement of the shilling rate of payment, who attended in one week, was in the week ending August 30th, when the police returns gave 211,446 as the number who entered the building. The largest attendance in any one week was that of the last, when the same source gave the following as the amount—518,277, or rather more than half a million of people in six days! The largest of the average daily attendances was on a shilling day, the 15th of July—Tuesday, when the numbers were 74,122. The smallest daily attendance was the first shilling day, Monday, May 26th, when the numbers were 25,402. The smallest actual daily attendance was on a five shilling day, Saturday, July 19th, when only 9,327 persons entered the Exhibition building.

The last week was in every respect an eventful and a remarkable period. The statistics of that week are extremely interesting, and are given below.

Date.	Day of the week.	Number of persons paying at the doors.	Fee.		Amount received.			Season tickets.	Total.	Largest number at one time.
Oct.			s.	d.	£	s.	d.			
6	Monday	103,506	1		5,175	16	0	4,299	107,815	89,242
7	Tuesday	104,630	1		5,231	10	0	5,285	109,915	93,224
8	Wednesday	105,663	1		5,283	4	0	4,097	109,760	87,275
9	Thursday	86,887	1		4,344	7	6	3,926	90,813	72,344
10	Friday	39,312	2	6	4,914	1	6	7,601	46,913	39,767
11	Saturday	38,765	2	6	4,845	13	6	14,296	53,061	45,067
		478,763			29,794	12	6	39,504	518,277	

Of one of the days of this eventful week, the following account was written at the time, and appeared in one of the daily journals; it is so remarkable as to deserve preservation.

"Yesterday at the Exhibition will not soon be forgotten, and we may safely say that it is without a parallel in history—upwards of 100,000 persons having entered one building in one day. The exact number was 107,815.

"The numbers were at—

10 o'clock	10,090
11 "	35,404
12 "	64,157
1 "	84,701
2 "	97,887
3 "	104,263
4 "	107,815

"Soon after ten o'clock the crowd around the eastern entrance was so great that, the usual turntables were dispensed with, and the visitors were allowed to enter without that check, the superintendent, and the various money collectors, taking the money as fast as it could be poured in; and for the space of two hours they had to endure a silver shower such as has seldom been witnessed.

"Shortly after three o'clock, and when about 90,000 persons were in the building, the Duke of Wellington entered at the east end, and was loudly cheered by those who recognized him. The intelligence soon spread in the eastern half of the building, and a sensation of apprehension was created as to the result. Thousands ran along the galleries, and each avenue poured its torrent into the nave, while large numbers in the transept, hearing the distant noise, and seeing the confusion, but ignorant of its cause, rushed out of the building under the apprehension that some casualty had occurred. By dint of pure physical force, the police-officers succeeded in opening a narrow pathway for the duke—who, after having passed through the eastern half of the building, left at the southern entrance, where he mounted his horse, and departed amid the cheers of thousands outside the building. It is most satisfactory to state that not a single accident occurred; and those who have on former occasions favoured the public with their opinions as to the destructive effect of the rapid and irregular movement of an immense crowd upon the building, will be surprised to hear that not a single girder or 'snag,' has given way; and we may add that, although upwards of 89,000 persons were present in the building, there were many portions of it which were comparatively unoccupied by the masses, the nave and transept being of course the most crowded portions.

"The hourly returns of the numbers formed, during the day, the subject of intense interest; betting was carried on to an enormous extent, and we are informed that upwards of 100,000*l.* was entered in various books as to the result. For some time past, we believe, five to one has been very generally offered, and taken, that the number of visitors would in no one day exceed 100,000. The services of the electric telegraph were in constant requisition throughout the day."

It is interesting to turn from the contemplation of these immense multitudes daily thronging toward and into one great structure, to a short consideration of their individual characters. It is of course obvious that a large number of the visitors to the Exhibition were inhabitants of the metropolis; but these, although large in number, by no means constituted the majority, but rather the minority, and very considerably so. A vast throng was formed by the visitors from the country, and another by those from abroad; and into these three great classes the public who entered the Exhibition might be divided, namely, the inhabitants of the metropolis, strangers from the country,—that is, from all parts of the United Kingdom,—and visitors from abroad. Each of these classes might have been recognized without difficulty: the metropolitans were distinguishable by that comparative gentility of dress and want of freshness of complexion, which mark the occupant of this city; the visitors from the country by their looks of ruddy health, and perhaps by their expression of intense amazement; and those from abroad by those characteristics which are rather national than local, and at once define the appearance of one whom we call a foreigner. It had been originally thought that crowds of strangely dressed persons would be seen occupying the avenues of the Exhibition, but the result proved quite the contrary; for very few such really appeared; not, probably, because few foreigners, whose national costume widely differs from our own, were present, but from a very natural desire to avoid an undesirable publicity by want of conformity to the unobtrusive style of English dress.

It was highly interesting also to observe the desire for instruction evidenced by many who there attended; while the peculiar taste or pursuits of each led them to those portions of the building where the objects with which they were most familiar were arranged. Thus the agriculturists would be found thronging around the implements and machines in Class 9, which were devoted to that pursuit: the mechanic would spend the greater part of his visit among the varieties of steam-engines, and manufacturing machines: and the manufacturer would be seen busily examining the productions of rival looms, or of other works than his own. To those persons the display, grand as it undoubtedly was, never lost its more enduring character of one of deep and lasting instruction, and the ideas to which it has given birth will no doubt receive their development in many different directions for years yet to come.

One of the most affecting and pleasing scenes presented by this great attendance of visitors was the constant presence among them of a large number of schools of children, many of whom were dependent upon private charity; and all were destined to labour themselves in some department or other of the industrial arts. Thousands of children visited the Exhibition, some more than once—at the expense of benevolent individuals, and were thus enabled to obtain a conception of its varied wonders that no lapse of time will be able to efface from their memories. Many of the poor were also thus privileged—persons who could not themselves have spared the trifling sum of admission—and it was to any right-minded person a delightful spectacle to witness the poor enjoying in common with their wealthier neighbours a spectacle which will probably never again be reproduced, or, if ever, not with the same interesting associations as then. It is estimated that while the Exhibition remained opened to the public the children of no fewer than 510 schools, amounting to 43,715 pupils, visited it; and the kind feeling exhibited by the wealthy classes towards the poor may be further inferred from the fact, that nearly 11,000 persons, in addition to these, were treated to a visit to the Exhibition at a total cost of £2,735 paid for admissions, to say nothing of the much larger sums disbursed for their conveyance to and from the building. Persons being allowed to bring their provisions with them, it was no uncommon sight to behold in some of the side avenues hundreds of country people and others enjoying, apparently with peculiar pleasure, a meal in the palace of glass, or a draught from the crystal fountain. The labourers from many estates around London, and the work-people from many factories were visitors at the Exhibition. From the country, by monster trains, came the clubs of working men; and in vans, variously decorated, and always densely thronged, came holiday-makers from all parts of the metropolis, and its immediate suburbs. From abroad came crowds of artizans, of tradespeople, of manufacturers, and of private gentlemen.

Among other visitors was a fisherwoman, who had walked up from one of the ports of Cornwall, having taken five weeks to perform her pilgrimage to this shrine of art and industry. She was eighty-four years of age, appeared a remarkably hale and hearty-looking individual, and attracted considerable notice. The French department was that in which she seemed to be most interested. This person spent several days in visiting the Exhibition, after which she returned to her home in the country, full of wonder and surprise at all she had beheld. It would be a grave omission to advert to the visitors of this scene without allusion to the sovereign of these realms, who with her distinguished husband, the promoter of the vast undertaking, almost daily examined its contents, and obtained so complete an insight into the different departments that not a single article of importance escaped their recognition, whilst many were honoured with their expressed approval.

It may serve to give an accurate idea of the amount of travelling produced by this event, to state that the Great Western Railway, in the middle of the summer, had an increase of traffic amounting to 56·21 per cent. over the corresponding period of the preceding year. The South-eastern railway exhibited an increase of 30·7 per cent. The South-western of 40·9 per cent. The South Coast Railway of 12·1 per cent. The Blackwall Railway of 31·9, and the London and North-western of 28·9 per cent. From these facts it is evident that the interest felt in this undertaking was experienced pretty equally in every part of the country, the traffic being most upon those lines of railway which formed the channels of communication with the most extensive districts.

In pursuing this superficial sketch of the general history of the Exhibition, it may be interesting to mention, without any attempt at connection, a few miscellaneous facts which link themselves thereto. In giving the returns of the visitors it must not be forgotten that the staff of the executive and the attendants of exhibitors must also be included in it. On considering the vast extent of the structure, and the perfect order in which every part of it was maintained throughout, doubtless the inquiry has often been made as to the number of persons required for this task. We are able to supply this information: of superior officers, inclusive of the executive committee, the superintendents, inspectors, clerks and collectors — there numbered ninety-six; of police there were three hundred, of sappers and miners two hundred, and of attendants twelve hundred. The total number of persons of all descriptions, in official connection, or otherwise occupied in the building, was about two thousand one hundred and thirty! On one occasion, when it was necessary to dust all the girders and columns of the interior, in consequence of the accumulation of dirt which was found to have got upon them, one hundred and sixty persons were employed as dusters—and in the interval from five o'clock in the morning to half past eleven in the day, this immense task was got through.

The electric telegraphs which were arranged in different parts of the building deserve to be noticed. At little stations in the galleries and at each of the entrances were placed instruments which were in connection with some of a similar kind, fixed in the office at the south entrance. These small telegraphs were of a very simple kind, although capable of transmitting any intelligence. They were principally used for summoning the carriages of visitors, or for communicating information to the police. In the police station, immediately in front of the southern entrance, was another telegraph the wires of which were in communication with important public offices. Every event which occurred in the building was thus instantly communicated to persons in authority; and had it been necessary to apply for an additional force, the application might have been instantly made without the knowledge of any but the inspector and worker of the instrument, The telegraphs in the office at the south entrance were in communication with the various railway lines. On one occasion, when Her Majesty and Prince Albert visited the building at their usual early hour, they first went to the offices of the electric telegraph company. The company's principal engineers being in attendance to give explanations, communications were then opened with Birmingham, Manchester, Normanton, Newcastle, and Edinburgh. An order was sent to the last-mentioned place, desiring that a message containing local news should be forwarded through the instrument. This was instantly done, with astonishing rapidity and success, and announced the arrival of the ex-royal family of France at Edinburgh on the previous evening. The sending of messages by the company's printing telegraph direct to Manchester, was also illustrated.

A most useful application of the electric telegraph was made during the period of the Exhibition. Intelligence was received every morning at nine o'clock of the direction of the wind and state of the weather and barometer in different parts of Great Britain. The system of meteorological observations thus established, furnished a series of most interesting results. By an ingenious chart, in which a number of movable arrows were placed, the direction of the wind in different towns was rendered evident to the eye; and it furnished matter for curious thought, that while a south wind was found to be blowing in London, a west, or even a north wind, was felt at Bristol or at Liverpool. If a sufficient number of such observations were put together and submitted to an accurate meteorologist, important facts might be deduced from them.

In the centre of the southern half transept many persons might have noticed a small upright pillar, on the top of which the ticket "Post" was placed. This was in fact a post-office of some ingenuity of construction. It was a hollow cylinder, with a mouth somewhat similar to that of a letter-box. It was used as such for the business of the Exhibition, and was made in imitation of those employed in Belgium. The business of the executive and others connected with the Exhibition, required the establishment of a post-office expressly for this purpose, and from the number of letters daily received and transmitted through it, an idea of the extent of the correspondence carried on may be formed. On an average it is stated that five hundred letters were despatched daily, and about three hundred were received. A number of visitors to the building frequently made use of the ingenious letter-box in the transept, for the mere singularity of forwarding a letter from the Exhibition. These letters did not pass through any branch office, but were daily sent to and fro by the instructions of the postmaster-general, from the Central Metropolitan Office.

In order to render the Exhibition instructive to those who could afford frequently to visit it, lectures were commenced about the middle of its history, which were intended to elucidate the peculiar features of interest presented by different classes and sections. At first these lectures were attended by a few hearers, but their number constantly diminished, until at length they were altogether given up. It appears singular that so valuable a means of becoming acquainted with the most interesting objects of the Exhibition should have thus proved unsuccessful. The fact, however, seems to have been that there was too much to be even inspected to admit of time for lectures on particular subjects. Had the exhibition been a permanent undertaking, there can be little question but that this means of instruction would have been largely availed of; but during its short history almost every visitor appeared to feel that time was wanting to become thoroughly acquainted with its details, and those who were most frequently present, expressed their regret at the very partial knowledge they had gained of the display as a whole.

A more ready method of viewing the wonders of the Exhibition, was that of taking one of the appointed guides for that purpose. This simple arrangement was not in existence until some time after the opening, and was instituted to meet a very general want. The task must have been of an arduous kind, and as the guides could not be expected to be familiar with all the interesting objects, special guides for the machinery and scientific apparatus were in requisition. The catalogue, simple though its arrangement really was, proved of but limited utility, owing either to the hurried attempt to see all at once which caused it to be neglected, or from a misapprehension of the method of using it. This was in truth extremely easy and commodious. Tickets were placed on the stand of every exhibitor with his class, or country, and number distinctly printed on them. By simply referring to that class or country, and the number under it, in the book, a short description of the articles would be found in it. The larger catalogue only appeared in parts, and was not actually completed until a day or two prior to the close of the Exhibition, when its assistance was unavailable.

The temperature of the building during this period was subject to great fluctuations, dependent not alone upon those of the attendance, but upon the proverbial unsteadiness of our weather. It is remarkable that the whole period of the Exhibition was attended with extremely fine weather, that is, with great absence of rain, but the range of daily temperature was frequently very considerable even under the most settled sky. From the 25th of April, the mean temperature continued below the average of the same period for the preceding ten years, as much as 4° Fahrenheit up to the 19th of June—after which the thermometer in the open air gave 3° daily in excess of the average. On that day the thermometers in the interior of the building were found to exhibit a sudden rise in the mean temperature of the day amounting to 10°; the 18th showing 64° 8′, and the 19th 74° 8′. This was a shilling day, with 63,863 visitors. The temperature increased until the 26th of the same month, when the thermometer rose to 2° above summer heat, viz., 78° 6′. On that day the mean was the highest that had been felt during the Exhibition. At 4 p.m. a thermometer placed in the north-east corner of the gallery, among the wax flowers, registered 97°, and the air was not only hot, but vitiated. In order to obviate this extreme temperature, and to secure a fresher supply of air, the glass ends of the building at the entrance were removed on the 2nd of July, upon which the thermometer exhibited a depression of from 79° 4′ to 66° 6′. After this alteration 73° 4′ was the maximum, with one exception.

Still a difficulty of breathing was felt in the galleries. The rarified air, caused by the crowd below, filled the galleries, where the heat averaged 4° above that of the main avenue, and was frequently even higher still during the crowded hours of the day. The relief experienced by the removal of the glass below, suggested a similar step for the galleries. Accordingly, on Monday, the 7th of July, glazed arches at various parts in the galleries were removed. After this the temperature in the galleries and on the ground floor became more uniform, and was found to be under control. The effect of the changing numbers of the visitors, in elevating or depressing the thermometer, was remarkably shown on the 19th of July, when Saturday, with its five-shilling admission, brought a thin attendance (9,326). A transition even in July from heat to cold was felt throughout the building, and the thermometer only registered 59° Fahrenheit.

It is very generally the painful part of the historian, of any great public event, to have to narrate the occurrence of losses of life or accidents of some fatal character; but the history of the Exhibition is happily free from those in a manner so truly remarkable, that the circumstances duly considered, it cannot but be evident that a kind overruling of Divine providence attended every part of this momentous undertaking. The most ordinary event of any public interest which attracts a crowd of persons together, is almost invariably attended with serious results to some few individuals, and such events are necessarily rare. But in the instance in question, an immense gathering of people, of daily occurrence, and taking place through several successive months, has met and dispersed absolutely without any accident, much less any fatal result. One or two instances of sudden deaths in a company of six millions of persons is only a natural average, and the same might have befallen in any other place. But no failure of the building, under pressure of the multitude, took place; no person received death by pressure, or by being trodden under foot of the crowd; no person by imprudence got entangled in the machinery, of which so many specimens were in rapid action; and such an occurrence could not but have entailed the most fatal consequences. One or two slight accidents occurred to the attendants; but among the visitors there is no single record of danger, much less of death from these causes. On one occasion, whilst the Exhibition was overflowing with visitors, a most dreadful accident had nearly been brought about. A balloon had been cast off from some place of public resort in the vicinity. The machine at first ascended rapidly, but then began to fall with equal rapidity, and was borne by the wind in the direction of the Exhibition building. At this moment all who witnessed the career of the machine were filled with apprehension from the anticipated results of its coming into collision with the structure. A quantity of ballast was thrown out, and the balloon gradually rose as it approached the building; but a more formidable accident appeared now to be impending. The grapnel of the machine hung suspended in the air, and if it became entangled with the roof, the consequences to the multitude beneath it, from the resulting panic, and destruction of the timber, &c., no human being could estimate. The wind still carried on the machine, and the line barely touched the roof, without injuring it, beyond carrying away one or two flag-staffs at one end. Thus passed this great danger by.

One of the disadvantages of the open flooring of the building was the danger of losing any articles dropped through the crevices. But that this was not the only place of deposit for lost things may be estimated from the following amusing list of articles found by the police;—"275 shawl brooches and clasps, 319 pocket-handkerchiefs, 69 shawl pins, 16 pocket and memorandum-books, 13 pencil-cases, 67 bracelets, 43 walking-sticks, 48 veils and falls, 1 flask, 1 opera glass, 168 parasols, 32 umbrellas, 31 reticules and other baskets, 28 bunches of keys, 14 victorines, 49 neck ties and cuffs, 8 bonnet shades, 18 pairs of spectacles, 4 ladies' season tickets, 1 gentleman's ditto, 38 pairs of gloves, 22 bags of various colours, 7 shirt studs, 2 ladies' pockets, one containing 6½*d.* in copper; 4 snuff-boxes, 10 watch-keys and seals, 1 cape, 1 overcoat, 3 boys' caps, 3 fans, 10 lockets, various; 1 petticoat, &c."

Before approaching the closing ceremony of this great event, it is important to advert to the system of awards adopted with reference to the merits of the exhibitors of different classes and countries. The following general principles on which these awards were to be made, have a degree of permanent interest attaching to them, since they indicate in each of the sections of the Exhibition, those qualities, whether of raw materials, machinery, manufactures or plastic art, which are considered to possess the highest merit.

"In the department of raw materials and produce, prizes will be awarded upon a consideration of the value and importance of the article, and the superior excellence of the particular specimens exhibited; and in the case of prepared materials, coming under this head of the Exhibition, the juries will take into account the novelty and importance of the prepared product, and the superior skill and ingenuity manifested in the process of preparation.

"In the department of Machinery, the prizes will be given with reference to novelty in the invention, superiority in the execution, increased efficiency, or increased economy in the use of the article exhibited. The importance, in a social or other point of view, of the purposes to which the article is to be applied, will also be taken into consideration, as will also the amount of the difficulties overcome in bringing the invention to perfection.

"In the department of Manufactures, those articles will be rewarded which fulfil in the highest degree the conditions specified in the sectional list, viz., increased usefulness, such as permanency in dyes, improved forms and arrangements in articles of utility, &c. Superior quality or superior skill in workmanship. New use of known materials. Use of new materials. New combinations of materials, as in metals and pottery. Beauty of design in form or colour, or both, with reference to utility. Cheapness, relatively to excellence of production.

"In the department of Sculpture, Models, and the Plastic Art, the rewards will have reference to the beauty and originality of the specimens exhibited, to improvements in the processes of production, to the application of art to manufactures, and, in the case of models, to the interest attaching to the subject they represent."

A difficult and delicate task was that of selecting the persons who were the most fit to examine the productions of exhibitors, and to decide as to their respective merits, and to make the ultimate awards. Much pains was taken to obtain jurors whose position and reputation alike rendered them competent judges and impartial examiners. There were a number of distinguished foreigners among the jurors, who appeared as the representatives of their own countries. It is unnecessary to advert at greater length to this part of the arrangements. It may however be stated that the awards which at first were to have been in money in part, were ultimately made in bronze medals, and the nature of merit rewarded was distinguished by the Council Medal, the Prize Medal, and Honourable Mention. Every exhibitor was to receive a medal in commemoration of the event, and a copy of the juries' report. There has been much discussion as to the expediency of any principle of awards in this undertaking, and a somewhat happier termination of the whole might have been brought about had the entire system of awards never been entertained. It should not be questioned that impartiality influenced the decisions, but it is always difficult to satisfy the disappointed as to the degree of justice with which they have been regarded, —and, indeed, this might have been foreseen from the first.

On Saturday, October the 11th, 1851, the Great Exhibition, to the general public, closed its eventful career. Perhaps no portion of its history was so remarkable as that week, the last day of which saw its portals for ever shut to the visitor. On three successive days upwards of one hundred thousand human beings had entered, examined, and departed wondering from the immense building. The last day had been a full attendance, and towards its close it was anticipated that some ceremonial would take place. This anticipation was, however, realized simply by the singing of the National Anthem. There was a touching and remarkable reluctance manifested to quit the scene where art and industry had for the first and last time met in public display, and after some confusion, and in the midst of a deafening noise of bells and gongs, the police succeeded in clearing the building, the last visitor departing from it at half-past six in the evening.

The following Monday and Friday were appropriated to the exhibitors and their friends, who were permitted free entrance to the building. The final closing was on Wednesday the 15th of October. It was expected that the peaceful termination of this eventful undertaking would have been marked by some special ceremony of an imposing character, but it will be seen from the following account that it was, on the contrary, one of great simplicity, and devoid of any attempt to offer a parallel to the wonderful spectacle of the opening day. Exhibitors and jurors only were admitted on the 15th of October. On entering the building the place occupied by the crystal fountain was now covered with a large platform, and this trophy of the glass-makers' art, with that of the silk-loom in the western avenue, and the great diamond, were among the first objects removed for ever from public inspection. The first signal of the universal removal that was shortly to take place was thus given. At twelve o'clock the Prince, accompanied by the royal commissioners, entered the building, and proceeded to the platform, while a large number of persons sang the national anthem. The report of the jurors was then read, and on being received by the Prince, was responded to by him in a speech of which the few closing sentences are here subjoined.

"In now taking leave of all those who have so materially aided us in their respective characters of jurors and associates, foreign and local commissioners, members and secretaries of local and sectional committees, members of the Society of Arts, and exhibitors, I cannot refrain from remarking, with heartfelt pleasure, the singular harmony which has prevailed amongst the eminent men representing so many national interests—a harmony which cannot end with the event which produced it. Let us receive it as an auspicious omen for the future; and while we return our humble and hearty thanks to Almighty God for the blessing he has vouchsafed to our labours, let us all earnestly pray that that Divine Providence, which has so benignantly watched over and shielded this illustration of Nature's productions, conceived by human intellect and fashioned by human skill, may still protect us, and may grant that this interchange of knowledge, resulting from the meeting of enlightened people in friendly rivalry, may be dispersed far and wide over distant lands; and thus, by showing our mutual dependence upon each other, be a happy means of promoting unity among nations, and peace and good will among the various races of mankind."

This was succeeded by the singing of a fresh portion of the national anthem. After this was concluded, the Bishop of London offered the following prayer of thanksgiving—of which we make an extract as far as it refers to the great undertaking itself, and its appropriate and beautiful language well expresses the feelings of every right-minded Christian present at such an occasion as that of its offering.

"O Almighty and most merciful God, Father of all mankind, who hast made of one blood all nations of men, to serve and worship Thee, and by their words and works to glorify Thy holy name; who didst send Thine only Son into the world to reconcile it unto Thee, and to unite all men in one brotherhood of holiness and love; we, Thine unworthy servants, most humbly beseech Thee to accept our offering of prayer and praise. From Thee alone proceed all good counsels and all useful works; and by Thee alone are they conducted to a prosperous end.

"We acknowledge, with all humility and thankfulness, the gracious answer which Thou hast vouchsafed to the prayers of our Queen and her people, in blessing, with a wonderful measure of success, an undertaking designed to exhibit the glories of Thy creation, to promote the useful exercise of those faculties which Thou hast implanted in the sons of men; and to encourage the growth of peace and brotherly love.

"We humbly thank Thee, O Lord, that Thou hast graciously prospered the counsels of him who conceived, and of those who have carried out that great design; and that Thou hast mercifully protected from harm the multitudes who have thronged this building. We acknowledge it to be of Thy goodness, that a spirit of order and mutual kindness, of loyalty to our Sovereign, of obedience to our laws, and of respect for the sanctity of Thy Sabbaths, has been manifested by the people of this country, in the sight of those who have been here gathered together from all parts of the world.

"We thank Thee, also, that Thou hast disposed the hearts of many nations to enter upon a general and peaceful competition in those arts which by Thy merciful appointment minister to the comfort of man, and redound to Thy glory as the Giver of every good and perfect gift.

"We devoutly pray that all may be led to acknowledge Thy power, wisdom, and goodness, in the achievements of man's industry and skill; and may depart to their several homes 'to speak in their own tongues the wonderful works of God.' Continue to them, we beseech Thee, Thy favour and protection; let Thy good Providence conduct them in safety to their native land; and bless them with prosperity and peace. Grant, O Lord, that this gathering of Thy servants from every nation may be the token and pledge of a continued intercourse of mutual kindness between the different branches of Thy universal family. May it contribute to the growth of Christian love, and hasten the coming of that blessed reign of peace, when 'nation shall not lift up sword against nation, neither shall they learn war any more.'"

At the conclusion of this prayer the hallelujah chorus was sung, and the ceremony of closing the Great Exhibition was ended. The Prince withdrew from the building, and the scene was over.

The names of the exhibitors who had obtained medals or honourable mention, were published by authority on the same day. Of the productions or processes, such exhibitors as in certain classes have received these awards, other portions of this work are intended to treat. The following, however, gives a general idea of the extent of merit in the Exhibition, and of the labours of the jurors in rewarding it. "A careful examination of the aggregate result of the labours of the jurors shows that the number of awards of all classes—council and prize medals, and 'honourable mentions'—is 5,084; of this number 2,039 have been awarded to the United Kingdom, and 3,045 to the foreign exhibitors. Upon analyzing these lists, we find that the proportion of prizes awarded in the six great groups which included the whole of the jurors, is as follows:—

RAW MATERIALS.—CLASSES I. TO IV.

	British.	Foreign.	Total.
Council medals	6	16	22
Prize medals	125	437	562
Honourable mention	131	535	666
Total	262	988	1,250

MACHINERY.—CLASSES V. TO X.

	British.	Foreign.	Total.
Council medals	52	36	88
Prize medals	301	191	492
Honourable mention	51	114	165
Total	404	341	745

TEXTILE FABRICS.—CLASSES XI. TO XXV.

Council medals	1	2	3
Prize medals	337	498	835
Honourable mention	185	277	462
Total	523	777	1,300

METALLIC, VITREOUS, AND CERAMIC MANUFACTURES.—CLASSES XXI. TO XXV.

Council medals	14	21	35
Prize medals	312	214	526
Honourable mention	208	199	407
Total	534	434	968

MISCELLANEOUS MANUFACTURES.—CLASSES XXVI. TO XXIX.

Council medals	4	10	14
Prize medals	142	232	374
Honourable mention	100	154	254
Total	246	396	642

FINE ARTS.

Council medals	2	2	4
Prize medals	27	60	87
Honourable mention	41	47	88
Total	70	109	179

Immediately after the close of the Exhibition the exhibitors lost no time in the removal of their articles. In one day the whole of the jewellery and articles in the precious metals was removed, and the same energy was displayed in other departments. Before the expiration of one week the aspect of the interior of the building had undergone a wonderful change. The foreign side was barricaded from one end to the other, and in the hands of custom-house officers, while the British side was already half-emptied—of all the wonderfully rapid processes attendant upon the Exhibition, that of its dismantling was probably the most marvellous. As if by magic the populous interior became in one half of its extent an empty and deserted place. The same delay and procrastination which marked the progress of the foreign exhibitors, prior to the opening, was manifested after the close. For this were many reasons. The regulations of the customs' officers, the desire to effect sales of the articles exhibited, and a deficiency of any well-organized method of getting the goods packed and sent off. The clearing out of the building was not in fact completed until the end of the year 1851, when its vast interior was thoroughly stripped of all that had once communicated to it a degree of unparalleled magnificence and grandeur.

It may be expected that before concluding this chapter, some allusion should be made to the future destiny of the wonderful structure itself. At the time at which this page is written,* this still remains a matter of uncertainty. It may, however, be interesting to show how strict were the conditions of its removal after the close of the Exhibition, and we therefore add an extract from the official warrant for this purpose. It provides as follows:—" That the said Commissioners especially will, on or before the first day of June, 1852, take down and remove, or cause to be taken down and removed, all and every the buildings and erections which shall be built or erected upon or within the said site or piece of ground mentioned and described in the said royal warrant, of even date herewith, and delineated in the plan drawn in the margin thereof, and the materials thereof, and the implements employed in erecting the same, and all and every the articles or article, of whatever nature or kind, which shall or may be brought to or upon the said site or piece of ground for the purpose of the said Exhibition, and will at their own expense in all respects restore the soil and surface of the said park to the form in which it was previously to the said Commissioners for the Exhibition of 1851 inclosing any part thereof, ready for sowing the same with grass seeds, and to sow the same, and that, if the Commissioners of her

* January, 1852.

Majesty's Woods and Forests for the time being shall deem the state of the ground insufficient, it shall be competent for them to restore the same to their own reasonable satisfaction, at the cost of the said Commissioners."

The building was, however, respited until May 1st, 1852, by consent of parliament. The architect, Mr. Paxton, proposed to convert it into a winter park and garden, effecting the following alterations in the structure and its design. "At the east and west ends, and upon each corner of the upper story, it was proposed to place two square chimneys, having the appearance of towers, and of a construction similar to the other portions of the building. The chimneys would consist of two tiers of arches similar in every respect to those in the exterior of the building, there being four arches upon each of their sides. At each corner of the second story or tier of the building would be erected towers of one tier in height, and formed of three arches upon each side. The effect of these towers would tend greatly to remove the monotonous and step-like appearance which the building in its actual state presents to view. At each end of the lower, ground story, a semi-circular sweep of columns would be added, for the purpose of affording greater scope for the artistic arrangement of the interior of the building. A grass plat, ornamented with statues would be placed at each end, with a broad gravel drive round the whole of the building."

The following are some of the proposed arrangements for the interior of this structure:—"In this Winter Park and Garden the trees and plants might be so arranged as to give great diversity of views and picturesque effect. Spaces might be set apart for equestrian exercise, and for carriage drives; but the main body of the building should be arranged with the view of giving great extent and variety for those who promenade on foot. Fountains, statuary, and every description of park and garden ornament, would greatly heighten the effect and beauty of the scene.

"Beautiful creeping plants might be planted against the columns, and trailed along the girders, so as to give shade in summer, while the effect they would produce, by festooning in every diversity of form over the building, would give the whole a most enchanting and gorgeous finish.

"Besides these there might be introduced a collection of living birds from all temperate climates, and the science of geology, so closely connected with the study of plants, might be illustrated on a large and natural scale, thus making practical botany, ornithology, and geology familiar to every visitor."

The annual expense is thus stated by Mr. Paxton.

Labour, fuel, water, implements, gravel for walks, feeding and attendance to birds, and general superintendence . . .	£8,000
Besides the above, constant painting and renewal would be required; for this a reserve fund should be provided, and by which the building might be renewed for ever . .	4,000
Making a total of . . .	£12,000

There are many grave objections which might be urged to this proposal which carries with it much that is pleasing and attractive. The obviously limited extent of its advantages—merely including those residing in its vicinity—the annual outlay it would entail—the extensive site of public ground already occupied by the building—the danger of an abuse of the purposes for which it would be kept up—and numerous other obstacles present themselves, and will no doubt receive due consideration. Perhaps the most wise and prudent measure would be its entire removal, certainly no other measure would so much enhance the popular appreciation of a scene which it is out of the power of man to recal. It has been ingeniously suggested that in the event of its removal the site of every column might be marked to posterity by planting young trees there, and a more appropriate method of commemorating the existence of the most wonderful building ever erected could scarcely have been thought of.*

Let us pause for a few moments before putting a period to this short and simple record of the great Industrial display of this century. It has been our earnest intention to avoid all bias in the account we have given in these pages. It is not for us to decide on the advantages or the contrary of an event like that we have endeavoured to commemorate. Future history will have to record them, and their development must be awaited. Every preconceived opinion which went before on this event has been so signally set aside, and in many instances upturned by the reality, that it were hazardous to anticipate what may arise out of it in future. It will be the hope and prayer of every Christian that God may so order and direct the issues of this memorable event as to cause them to work out His own glorious purposes: and to lead to the spread of the saving knowledge of His dear Son, the common and only Redeemer of all the nations of the earth, and to the wide diffusion of the Holy Scriptures.

A powerful and interesting picture of the effect produced by this event upon nations, merely as regards their individual movement, is presented in the following extract from a number of a journal published at the period of the Exhibition.

"Since the time of the Crusades, the populations of Europe have not been stirred by a common thought—set in motion by a common interest, as we have seen

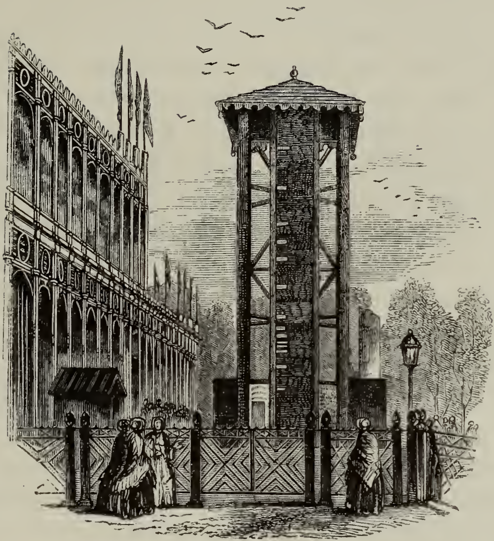
* Since this was written, Parliament has wisely decided on the removal of the Building. It has been purchased by a company for a sort of permanent exhibition at Sydenham.

them during the past summer. Not to this country or to that—the event now and hereafter belongs,—but to the world. The armies of Europe have often been arrayed against each other, and once within the memory of living men on the most colossal scale,—but the largest gatherings of men on battle-fields fade into insignificance before the mighty concourse which has this year gathered for brotherhood in Hyde Park. We must go back to romantic and fabulous times in search of parallels—and there shall fail to find them. The Goths who overran Italy—the invading army of Xerxes—the conquering hosts of Semiramis—dwindle away in face of the six millions of visitors to Hyde Park. Six millions! Let us for a moment compare this sum total with other well known figures. Of the sixty-two sovereign States of which Europe is composed, only eight have a larger population. Many nations, old and new, have made a distinguished figure in the world with less. The Athenian empire never reached so high a point. With half this number at his back, the Macedonian madman subdued Western Asia. At its proudest day the Venetian empire did not count so many subjects. At the present time, Holland has not half the sum,—Switzerland not more than a third. Denmark and Portugal combined do not reach the number. The united kingdom of Sweden and Norway contains little more than four millions. The entire populations of Bavaria and Wirtemburg could not by emptying themselves have supplied the streams of human beings flowing into Hyde Park this summer. Had every man, woman and child been swept from the dominions of the four kings of Greece, Wirtemberg, Saxony, and Hanover into the Crystal Palace, they would have failed to fill the space as it has been filled: —aye, even with the entire populations of the three imperial free cities, Frankfort, Lubeck, and Bremen, added! France alone has sent to our capital a host three times more numerous than Napoleon's famous Army of England,—Prussia has marched into our territory a larger force than the great Frederick ever commanded at one time,—Austria has poured into these northern islands more men than ever found their way through Brandenburg during the "Thirty Years' War." So far as Europe is concerned, there has been no movement of mankind so general as this in the historic times."

Many people truly have run to and fro, knowledge has been increased, and mankind appear to have advanced a stage nearer to that time when the end will come. May the testimony borne by us during our intercourse with the stranger, have been such as to comport with the character of a Christian people, and such as to leave a permanent impression for good upon all who have come to our shores. This gathering of the nations which has taken place has been at the summons of an earthly potentate, but the word of God gives the assurance that another, and a truly universal meeting of all the kindred of mankind shall take place. "It shall come," saith the Lord,—"that I will gather all nations and tongues, and they shall come, and see my glory."*

* Isaiah lxvi. 18.

CHAPTER XI.



MATERIALS OF INDUSTRY.—MINERAL SUBSTANCES.*

In further prosecution of the general plan of this work, we now propose to enter upon a short summary of the materials which supply to the industrial arts both the sources of power and the means of its development. The consideration of the materials of industry follows that of the Great industrial Exhibition by a natural order and sequence. For if we ask what has led to the wonderful triumphs of art and industry then and there displayed, one of the first replies must

* The cut represents a large pillar of coal erected at the west entrance of the Exhibition Building.

be the possession of suitable raw materials; the second being the enlargement and development of the right knowledge of their use. It is plain that the first precedes the second, for in the absence of a fit material the progress of knowledge is directly retarded by one of the most formidable obstacles. We can well conceive that the present advanced state of the steam-engine would not have taken place in a country the only profitable mineral wealth of which might have been gold or lead, iron and mineral fuel being scarcely to be found. We may with grateful humility thus remember that the source of much of the national greatness of this country depended not in the first instance on the superior talent or perseverance of its inhabitants, but upon causes over which they had no possible control,—upon stores of fit and readily convertible material lying in inexhaustible abundance beneath the soil. When therefore we regard with wondering the vast mechanical powers called into requisition by the erection of such a structure as the Exhibition Building, and still more when we contemplate its contents so far as they are the products of human industry, applied to materials of indigenous origin, let us not forget that to our raw materials, in an important sense, are we indebted for the present condition of these powers and objects—nor that such materials themselves, together with the developed faculties of their application, are the gift of God.

Most important of all materials in the wealth of a country is its fossil fuel; far more so than its vast areas of peat bog, or territories of forest wood. Both wood and peat are valuable in themselves, and their value increases in proportion as they form the only source of heat for domestic or commercial uses. But where coal is cheap and abundant no one would resort to their use for purposes either of convenience or economy. In the one condition we have fuel of low heating power, in proportion to its bulk; in the other of small bulk but great calorific value. The production of coal in nature follows the decomposition of vegetable matter previously in a growing state. We may therefore make brief allusion to the materials used for fuel before adverting to this, the most important among them.

Mankind, almost without an exception, resort to the combustion of carbon, in some form or other, for the extrication of heat for economical and other purposes. The process of combustion of this element consists simply in its union with oxygen derived from the atmosphere at a high temperature. The products are very varied, in consequence of the combination of other elements and substances with the carbon of the fuel. Could pure carbon be burnt as fuel, in the form of pure charcoal, or of the diamond, the products would be simply two gases, carbonic acid and carbonic oxide. But ordinarily a variety of fatty and resinous matters, and of mineral ingredients enter into the composition of fuel, even when peat or wood only are used, and the residual products are thereby rendered more complicated and various in their nature. Instances exist in which unusual sources of fuel or of heat are opened by the ingenuity or adaptive faculties of individuals; and among such may be ranged the application of combustible gases, issuing from the interior of the earth, to domestic uses, and even in a recent instance in our own country to the furnace of the boiler of a steam engine. In volcanic countries, also, as in certain parts of Tuscany, the heated products of decomposition, going on far below the surface, become a supply of caloric, even for manufacturing uses. But these instances are altogether exceptional; and the remarkable fact still remains that man is dependent chiefly on the element carbon, often associated, if not indeed always, with hydrogen, a gaseous element, for his source of artificial fire.

This fact is sufficiently observable, and deserves attentive consideration for the following reasons. The combustion of carbon and hydrogen produces carbonic acid gas and water—and these are the food of plants. Thus the vegetable kingdom, which is in the first instance the source of the fuel, becomes on its destructive decomposition, the receptacle of its elements, which, in obedience to vital laws, again take form and assume a solid substance, presenting to man a second time fuel for his varied uses. And so on continually. In this grand, yet simple phenomenon of nature, the fable of the phœnix, which looks like a gleam of truth caught far back in history, is beautifully realised.

To the vegetable kingdom we are therefore to look for the ultimate sources of fuel of all descriptions, whether fossilized or otherwise. Peat and turf, lignite, coal of all kinds, wood, and the products of these, such as artificial fuel, charcoal, coke, &c., are all either directly or indirectly derivable from the world of plants. The gradual decompositions which terminate in the production of peat, or lignite, or coal, are very interesting, but are not suitable subjects for discussion in these pages. The natural formation of peat and turf has been described in the following accurate terms in the "Bog Report" of Mr. Nimmo. He says, referring to cases where clay spread over gravel has produced a kind of puddle, preventing the escape of the waters of floods or springs, and when muddy pools have thus been formed, that aquatic plants have gradually crept in from the borders of the pool towards their deep centre. Mud accumulated round their roots and stalks, and a spongy semi-fluid was thus formed, well fitted for the growth of moss, which now, especially spears of *Sphagnum*, began to luxuriate; this absorbing a large quantity of water, and continuing to shoot out new plants above, while the old were decaying, rotting, and compressing into a solid substance below, gradually replaced the water by a mass of vegetable matter. In this manner the marsh might be filled up, while the central or moister portion, continuing to excite a more rapid growth of the moss, it would be gradually raised above the edges, until the whole surface had attained an elevation sufficient to discharge the surface water by existing channels of drainage, and calculated by its slope to facilitate their passage, when a limit would be, in some degree, set to its further increase. Springs existing under the bog, or in its immediate vicinity, might indeed still favour its growth, though in a decreasing ratio; and here, if the water proceeding from them were so obstructed as to accumulate at its base, and to keep it in a rotten fluid state, the surface of the bog might be ultimately so raised, and its continuity below so totally destroyed, as to cause it to flow over the retaining obstacle, and flood the adjacent country.

In mountain districts the progress of the phenomenon is similar. Pools, indeed, cannot in so many instances be formed, the steep slopes facilitating drainage, but the clouds and mists resting on the summits and sides of mountains amply supply their surface with moisture, which comes, too, in the most favourable form for vegetation, not in a sudden torrent, but unceasingly and gently, drop by drop. The extent of such bogs is also affected by the nature of the rock below them.

As thus represented this material is composed simply of a mass of plants in a state of decomposition. But ordinarily peat and turf contain a variable proportion of mineral substances, which is found to increase with the depth at which it is extracted. A specimen at the surface yielding only a trifling per centage of ash on combustion, and one at twenty feet in depth yielding perhaps as much as ten per cent of ashes. The economical value of the best description of this kind of fuel may be estimated and compared with that of other sources of heat, by the number of pounds of water evaporated by a given weight. One pound of the best turf collected and dried in the ordinary way will evaporate about five and a half pounds of water. The character of the fire it makes, a fire of great flame, but little intensity, is familiarly known. Turf is employed for various manufacturing purposes, where it is obtainable in sufficient abundance, and as fuel for steam engines. It also forms the domestic fuel of a large proportion of the peasantry in Ireland, and in other countries where natural circumstances render it available.

Turf and peat have of late come into unusual industrial prominence, and it has become a question of some importance whether the vast resources of these materials possessed by Ireland, forming, according to calculations, one-seventh part of that island, cannot be turned to useful account. The destructive distillation of peat in cast-iron vessels, supplies a large number of curious and interesting chemical products. In the Great Exhibition a remarkable series of these was exhibited, together with a variety of specimens of peat from various sources. The following list may supply some idea of the refinements of analytical chemistry, which have brought to light so many curious compounds, all derived from this substance of such familiar knowledge. The list given below is simply the exhibitor's description of his products, and as such is more instructive than a more formal arrangement of the substances.

"Ammoniacal liquor; the watery product of the first distillation from peat.

Sulphate of Ammonia; liquid ammonia; acetate of lime; and pyroligneous acid.

Paranaphthadipose; the general crude product of the first distillation from peat.

Peatole; the heavy oil from paranaphthadipose, first distillation; the same rectified.

Peatine, the peat from paranaphthadipose.

Peiipione, the light fatty oil of peat obtained from peatole.

Adiposole, fatty part of the residue of the distillation of paranaphthadipose.

Peatpitch, pitch-like part of the residue of the distillation of paranaphthadipose.

Adipolein, residue after the distillation of peatole and peatine.

Peacerine, waxy residuum of re-distillation of adiposole.

Paraffine, product of the forced distillation of adiposole.

Bisulphuret of carbon, or spirit of sulphur, obtained from sulphur and charpeat.

Sulphuretted peat charcoal, after having served to carbonize the spirit of sulphur (fit for making gunpowder).

Humic acid. Peat umber, obtained from certain peats.

Panel of oak, the graining effected with peat umber. Panel of rosewood, the graining effected with peat ulmine.

Peat blue; peat varnish; and peacerine heel-balls for shoemakers.

Huminate:—Stone's patent manures. Peat fire-lighters and revivers; peat plate powder."

Some of these products were very remarkable; perhaps among the most so, in its physical state and sensible qualities, was the peacerine above mentioned. This substance, which resembled a mass of pitch, and was of a waxy consistence, indented with the nail, was principally remarkable for the intense odour it emitted. If touched, this intolerable odour of concentrated peat-smoke adhered to the fingers with the greatest obstinacy. The varied application of these products from peat, above illustrated, is well deserving of notice.

The disadvantages presented by peat as a source of heat have been duly considered by inventors, and much ingenuity has been displayed in an endeavour to counteract these natural unfavourable qualities of peat-fuel. Pressure has been used to condense it, and a patent process exists in which it is condensed by centrifugal force, the peat being reduced to a pulpy state with water, and the water being then thrown off by the mass being set in rapid revolution. It may appear contrary to expectation, yet a mass of considerable density is thus obtained; but whether the process can be used with commercial advantage in point of economy, it is difficult to say; at first sight it appears improbable. By arranging the sods of turf or peat in the same manner as wood when it is to be converted into charcoal, peat charcoal, or more properly char-peat, is obtained. This product appears likely to be useful in various industrial processes.

Of wood as a direct source of heat for industrial use, there is no necessity to speak; something may, however, be spoken of its decomposition and ultimate assumption of the forms of lignite and coal. It is readily demonstrable that peat consists of an accumulation of vegetable matter composed of the plants of marshes, and of grasses mixed with other matters. Lignite, on the contrary, is formed from an accumulation of forest trees, which have undergone slow decomposition. Lignite, which is little known in England as a mineral fuel, yet exists in considerable deposits in this country. It is an imperfect kind of coal. Its vegetable origin is most distinctly shown in the woody structure revealed on a careful examination. The coniferous trees appear to have furnished the material for many large deposits of lignite. Some kinds of lignite appear to have only partially undergone decomposition, and are of a light horn colour, exhibiting most distinctly the usual characters of woody structure. As a source of heat, lignite is inferior to coal by about one-third, and the heat evolved is less intense.

In England, deposits of lignite occur to a large extent at Bovey Tracey, in Devonshire. It is also largely found in certain districts in Ireland, where it is used as a fuel. On the shores of Lough Neagh, it has been proved, that beds of lignite exist, the depth of which exceeds sixty feet. On the Continent this substance is of far greater importance than in Great Britain, where exists an abundant supply of a superior fuel. In Germany, especially, lignite is largely used and of very good quality. On the banks of the Rhine, in Nassau, in the Grand Duchy of Hesse, and elsewhere, important deposits exist, some of which are 120 feet thick. These lignites are valuable for fuel, but are too wet generally speaking to be fit for use at first extraction. Deposits of lignite have also been met with in India. Lignite beds also exist in immense quantity near the surface in the island of Trinidad. In New Zealand also, on the banks of the river Tamaki, near Auckland, deposits of lignite have been met with. In Austria lignite forms an important article of fuel. From what has been already observed, it will be understood that the use of lignite for fuel is only resorted to in such places as are not within reach of available supplies of coal. Its industrial importance is therefore dependent chiefly on the absence of the more important fuel coal.

Coal forms a material so immensely important to industrial progress, and to the development of every branch of the arts, that it may be regretted that but little space can here be devoted to its consideration. There is little doubt as to the true origin of coal lying in the decomposition of accumulated vegetable matter under particular circumstances: but, on examining the material itself, so entirely have its original characters been altered, that it gives little information on this subject. That person who took up a piece of coal for the first time, and minutely examined it, would not only be at a loss to account for its origin, but might, with some reason, question the statement of its original vegetable nature. This black, heavy, stone-like substance, was without doubt, however, once in the form of a living plant. A remarkable series of decompositions, prolonged through a considerable period of time, have terminated under the peculiar conditions in which the material was placed, in reducing the once delicately constituted tissues to a mass in which, only occasionally, is organized structure to be detected.

It is unnecessary to examine minutely into the received opinions as to the origin of coal. The most conclusive evidence is, however, obtained as to its being a vegetable product, the most remarkable markings of the leaves and stems of plants having been found in the coal strata; and these constitute such traces as leave no reasonable doubt on the subject. By carefully combining the information thus derived, it has been possible even to show the form of the plants, the remains of which constitute a great part of some of our coal deposits. The accompanying engraving represents these plants. Surprise will naturally be excited at their fantastic form and tropical character. No such trees as those represented, are now to be found in our own country, or in any other. They appear to have formed a part of the vegetation of a period of the history of our globe upon which we have, at present, no distinct and satisfactory evidence. The whole subject of the origin of coal is one which is enveloped in obscurity. We cannot obtain evidence of the birth-place of these trees, which must have required a tropical climate for their development, yet their remains are found in the coal-beds of Great Britain!

Neither can we learn the causes of their submergence, and of their having become stored up beneath vast

PLANTS FORMING COAL. (*Restored.*)

deposits of sand, clay, &c. Such is the present condition in which this substance is found. Buried deeply under beds of sandstone, shale, clay, &c., indicating distinctly a vegetable origin, though of mineral characters, and existing in certain well defined localities, coal has long presented to the geologist fond of speculations a theme of unusual interest and fertility.

The following account of the distribution of this important element in the industrial resources of a country, throughout the globe will be regarded with interest, and is given upon the authority of Professor Ansted:—

"Between the Arctic Circle and the Tropic of Cancer repose all the principal carboniferous formations of our planet. Some detached coal deposits, it is true, exist above and below those limits, but they appear, so far as we know, to be of limited extent.

"The coals of Melville Island and Byam Martin's Island certainly appear to be of the true coal period. We know that coal exists at numerous intermediate points, from the seventy-fifth to the twenty-seventh degree of north latitude in America, and also that it is worked on the Sulado and Rio Grande rivers in Mexico, for the use of the steamers.

"Southward of the Tropic of Cancer, the existence of coal, corresponding with the European and American hard coal, is somewhat uncertain. There seems to be none on the South American continent, unless it be at Ano Paser, which needs confirmation, or in the province of Santa Catherina, in Brazil. On the African continent we have had vague accounts of coal in Ethiopia and at Mozambique, also at Madagascar; and quite recently we have had intelligence of large quantities of coal in the newly-ceded territory above Port Natal, on the eastern side of Africa; but we believe no geologist has examined those sites. In the Chinese and Burmese empires only brown coal appears to approach the tropic, but true coal seems to exist in the northern provinces. Southward of the Asiatic continent we are uncertain of the exact character of the coal deposits, such as occur abundantly at Sumatra, Java, and Borneo, and neighbouring islands. Coal, however, exists in these islands, and is of fair workable quality.

"In New South Wales, the great coal-range on the eastern margin of that continent has sometimes been described as resembling the Newcastle coal in England, and sometimes it is described as of more ancient date. This coal differs essentially from that of any known European formation, but bears a strong resemblance to the Burdwan coal of India."

It is estimated that there exist about three hundred principal coal-fields in the known world. Some remarkable facts appear on an examination of the relative wealth of different countries in their proportionate treasures of coal. Thus considered, it will be found that England and Belgium are, in proportion to their extent, the richest with regard to the coal-fields which they contain. In this country the coal deposits are estimated at 1-20th of the total superficies of the kingdom, whilst in Belgium they are supposed to occupy about 1-24th of the entire surface of the country. In France all the known deposits scarcely occupy 1-100 part of the soil, and all the other European states are much poorer still in this respect. Sweden, Norway, Russia, Italy, and Greece are almost entirely without these formations. Bohemia is, in this particular, the richest part of Germany, although its annual production is far from being considerable. Spain, Portugal, Austria, and Poland have likewise their beds of coal; and the mineral is also more or less abundant in India, China, Madagascar, Van Diemen's Land, Borneo, and the other East India Islands, New Holland, and at Conception Bay in Chili. This formation is also extensively displayed in the United States of America, and in no part of the world are the beds of greater thickness, or more conveniently situated for the purpose of working. The annual production of coal by the mines of this country is estimated at 35,000,000 tons.

A great variety exists in the characters and consequently in the value of coal raised from different coal pits. And it is found that some kinds of coal are best adapted for some manufacturing purposes, and others for other uses. The common varieties are bituminous coal, steam coal, and anthracite. Among varieties of bituminous coal, the beautiful and remarkable substance called parrot or cannel coal is to be reckoned. This coal is remarkable for its property of ready ignition, and also of not soiling the fingers when touched. In consequence of the first of these qualities, it is often cut into long pieces and used in mining districts as a substitute for candles; and the latter renders it a suitable material for the manufacture of ornaments. Ornamental articles of this substance resemble jet, and the latter constitutes in fact a species of coal, for which purpose it is largely extracted at Whitby, and manufactured in Birmingham into brooches, &c. The chief industrial importance of cannel coal lies in the large amount of excellent illuminating gas which it yields by distillation. This gas is so pure and brilliant that the principal gas factories in the metropolis now obtain their supplies from the mines yielding cannel coal. It is sometimes wrought into garden seats, tables, &c., and one of the former articles was exhibited by His Royal Highness Prince Albert, at the Great Exhibition of 1851. The coal of which it was made, was obtained from West Wemyss colliery.

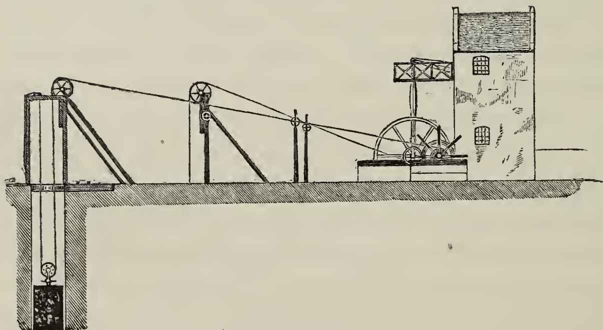
The ordinary coal used for domestic and manufacturing purposes varies of course with the source of supply. In the Midland districts of England, abundant supplies of coal are obtained from mines existing in various localities. This coal is of a bituminous kind, but is, in some respects, inferior to that of Newcastle. Some remarkable specimens of this kind of coal were shown at the Great Exhibition. The engraving at the head of this chapter represents a pillar of coal which was erected outside the building at its western extremity, and which consisted in reality of pieces from the different seams of coal, showing a section of the Barnsley thick bed of coal. Of these, some portions were adapted for domestic use, and some for steam-engines and manufacturing purposes.

A very beautiful description of coal obtained from the Silkstone colliery in the Barnsley district is called Iridescent or Peacock coal, from its beautiful play of colours. One of the monster specimens of inland coal exhibited is represented in the annexed engraving,

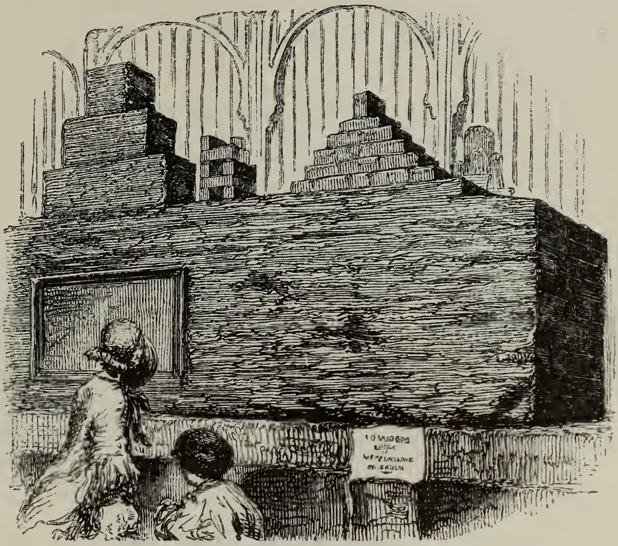
IMMENSE BLOCK OF COAL.

and shows in an interesting manner the extensive facilities for commercial traffic which must exist in this country, otherwise so large a mass could not have been conveyed from the mine to Hyde Park.

The extrication of this mass of coal is described in the following terms:—" Upon the first attempt being made, such was the great weight of the coal that the niche ring upon which the rope is wound broke through in two places, it being cast iron, six inches broad and one inch thick. A new niche ring being put on, a second attempt was made, when, amidst great suspense, the coal was brought to light up the shaft, 200 yards deep, in the space of three minutes. The waggons being run over the pit, the coal was landed, amidst the shouts and cheers of all assembled. The coal was then transmitted, by an incline railway of about 300 yards, to the wharf, the colliers holding it back by ropes. It had to be brought to the bottom of the pit some considerable distance, the ponderous mass at times breaking the cast-iron rails and sleepers forming the railroad, as it moved slowly along. The weight of the coal itself, exclusive of any chains, &c., is about five tons ascertained by means of steelyards. When lifted to be weighed, the hook by which the coal was suspended broke through, being of wrought iron, $1\frac{1}{4}$ inch square. The size is 6 feet high and 18 feet in circumference, necessarily of a circular shape to admit it up the pit shaft; the largest size that could possibly be produced, and probably the greatest weight ever attempted to be drawn out of a mine, and must have been attended with great risk to the machinery and ropes. No other than the 30 feet or thick coal seam of South Staffordshire, could allow such a large piece of coal to be produced. Its height upon the skip and waggon is nearly 9 feet. It is a fine coal, remarkably bright and clear."



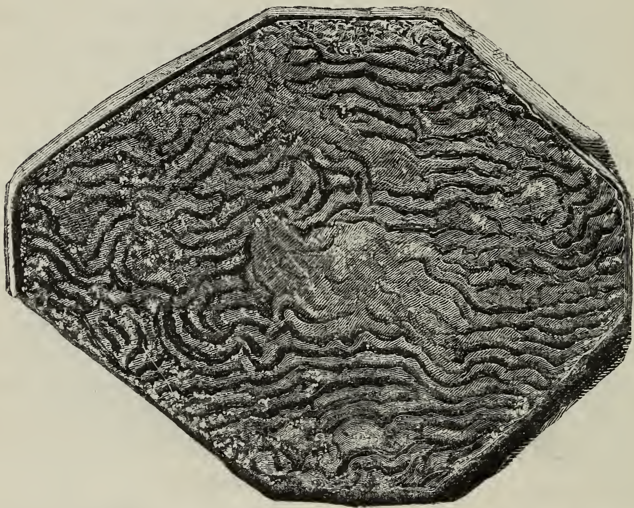
The above diagram exhibits the simple arrangements of the extraction of this block. Another specimen of remarkable size was interesting also from its physical characters. This mass is represented in the engraving. It was estimated to weigh not less



BLOCK OF STAVELY COAL.

than 24 tons. It was raised by the ordinary apparatus from a shaft 459 feet in depth. The mines are in existence at Stavely in the county of Derby, and are owned by the Duke of Devonshire. The dimensions of the block are as follows, 17 feet 6 inches in length, 6 feet in width, and 4 feet in thickness. The seam is 6 feet thick. The peculiar character of the coal is its disposition to a cubical fracture, so that with a very trifling amount of labour it can be split into square masses like bricks. It is thus well adapted for stowage as in ocean steamers.

The character of the fracture of different kinds of coal is sometimes remarkable. The annexed engraving represents in a striking manner the crystalline fracture of certain kinds of coal found principally in the Welsh coal pits. It is only rarely, however, that so perfect a specimen can be met with. The original, of which a photograph was taken, was exhibited in the Exhibition of 1851. This kind of fracture, though interesting, in itself gives no importance to the coal in an industrial point of view.



FRACTURE OF COAL.

Steam coals, of which various deposits in England are noticed, are much less bituminous than those ordinarily used for domestic purposes, and burn with a very small amount of smoke. They are, however, very important to the manufacturer, and are obtained in large quantities from pits in South Wales. These coals are less ignitable than the more bituminous kinds, but give out a great heat, and are found to evaporate a considerable amount of water per pound, whence their value for the navy and manufactures generally. Steam coal is also used in the manufacture of iron. It is altogether unsuitable for the production of gas, since it contains so small a proportion of volatile matter.

Anthracite or Stone coal is the only remaining variety of coals to which we think it necessary to allude.

"It consists," observes Prof. Ansted, "almost exclusively of carbon. This coal is also called non-bituminous, as the steam coal is semi-bituminous. The anthracites contain from 80 to upwards of 95 per cent. carbon, with a little ash, and sometimes a certain small per centage of volatile matter. They are heavier than common coal, take fire with difficulty, but give an intense heat when in full combustion with a strong draught. Anthracite occurs abundantly in the western part of South Wales, in the south of Ireland, in France, Saxony, Russia, and in North America, and the use of them is greatly on the increase. Amongst other things it is used for hop and malt drying, and lime burning with great advantage, but its chief use is in the manufacture of iron. The appearance is often bright with a shining irregular fracture; the coal is often hard, but some varieties are tender and readily fractured."

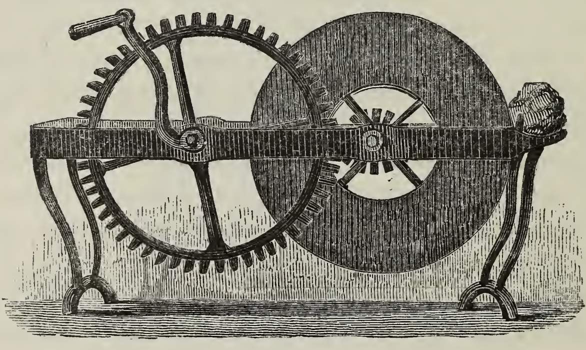
The accidents which have so frequently occurred in coal mines have made us painfully familiar with the risks attendant upon this department of industry. Of these, there are those which are common to all mining undertakings, such as the breaking of the lifting apparatus. And there is that more awful form of danger dependent on the accumulation of explosive gases, which is peculiar in a great measure to coal mines. The accompanying engraving represents an interesting and ingenious apparatus invented by M. Fourdrinier, in order to render the hoisting apparatus at all times secure, even if the left rope is broken; or the ring of the machine gives way. The ordinary mode of ascent and descent is simply by a tub suspended by a rope or chain. And if either of these break, the unfortunate miners are dashed to the bottom of the shaft to their certain destruction. The prevalence of these accidents may be estimated from the fact that, in one year, out of upwards of four hundred accidents which took place, not less than eighty-nine arose from breakage of ropes or chains. The apparatus represented in the cut appears to offer a simple and ingenious method of obviating these perils.

FOURDRINIER'S MINERS' APPARATUS.

The apparatus, which consists of a cage or basket, is attached to guide rods or chains down the side of the shaft, and in the fracture of the rope the self-acting springs or arms, forming levers attached to the top of the cage, are liberated, and these being wedged most securely upon the guide rods, the cage is fixed and its descent arrested. The apparatus has thus no chance of falling more than a few inches after the rope or chain is broken, and the stop is at the same time so complete that no danger is to be feared from any recoil. In an experiment made at Usworth colliery, Durham, the cage containing two tubs loaded with coal, the whole weight of cage, tubs, and coal being 48 cwt., when the rope was disengaged, the apparatus instantaneously took effect, and the whole mass was firmly fixed to the guides. On another occasion at the same colliery, the cage, with a total weight of 50 cwt., was safely arrested in its descent, which, but for the "safety" arrangement, must have been precipitated to the bottom of the shaft, 1000 feet below. But this was not all: two of the workmen then placed themselves in the cage, and by a touch of their hands, stopped this weight of 50 cwt., and themselves in addition, instantaneously; and so satisfied were four of the gentlemen present of its efficient nature, that they unhesitatingly committed themselves with a load of upwards of 40 cwt., to its protecting operations with the same successful results.

Another arrangement has been introduced, by which the casualties arising from the rope being drawn over the pulley are entirely prevented. This apparatus is perfectly self-acting, and the greater the weights which may be in the cage, the tighter do the wedges hold upon the guide-rods, in the event of any accident taking place.

The other source of peril to the miner is one of a much more dreadful character. It depends upon the accumulation of gases which, in becoming mixed with a certain proportion of atmospheric air, form a compound of the most dangerously explosive character. Many means have been suggested for the prevention of the fearful accidents which not unfrequently arise from this cause, and are always attended with great loss of life and property. Perhaps the most effectual is that of thorough ventilation of the mines by which the accumulation of the gases is entirely obviated; this, however, is frequently so costly an undertaking that it is not so carefully attended to as it deserves to be. The explosions are, almost in every instance occasioned by the use of unprotected lights, the naked candle, for example, of the miner. In some mines the effusion of explosive gas is so great, that it is absolutely impossible to work in them with unguarded lights. In such cases, the rude and cumbrous apparatus represented in the cut, was, until the



THE STEEL MILL.

invention of the Davy lamp, universally adopted. This apparatus is called the steel mill. It consists of a circular disc of steel acted upon by a cogged wheel, so as to be thrown into rapid revolution by turning a handle. Against the edge of this disc a piece of common flint was placed, and in the revolution of the disc a shower of sparks were struck out, which gave the miner a transient glimpse into the dark recess in which he was at work. Every time he required a light he had to use this miserable substitute for that purpose. Sir Humphrey Davy's invention is now so universally known that it is unnecessary to advert to it in any other manner than simply to state that it is a lamp protected by a guard of wire gauze, through which it is found that the flame will not pass, so that it cannot possibly communicate with the gas outside, and so cause an explosion. This lamp is largely used in many coal mines, but in others it is often to a lamentable extent set aside for the more simple, though dangerous expedient of the candle.

Anthracite is very commonly used for the same purposes as coke, where it can be obtained in sufficient quantity and at a cheap rate. But when anthracite is not to be had economically, it is then necessary for some manufacturing purposes to extract the bituminous properties from coal, and to reduce it to that state in which it is known as coke. Coal is for many purposes altogether unsuitable as a fuel, but particularly for stoves; for the intensely heated furnaces of the founder, and for locomotives. For these purposes a smokeless and clear-burning fuel is necessary, and it is essential that it should be such as to endure the intense heat of the furnace without running together as a caking mass, which bituminous and even semi-bituminous coals would do. For the purposes of heating stoves, the ordinary coke used is that obtained from the gas-works. Such coke is of small density, and is not difficult to kindle. It is the residuum left after the coals have been baked in the retorts for some hours, until all their volatile matter has been driven off, in the form of impure illuminating gas. Such coke is not, however, suitable to the purposes of the founder, nor for consumption in the furnace of the locomotive. The intense velocity and force of the current of air driven through these furnaces would dissipate its particles in showers of dust, and the high temperature necessary could never be obtained.

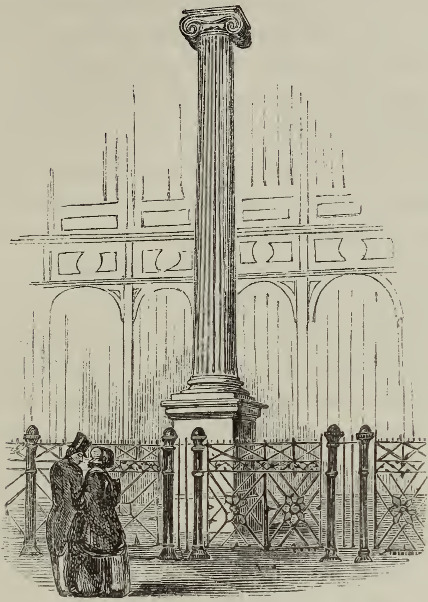
The coke required by the founder and for the locomotive, is made by the slow combustion of the gases of coal in an oven arranged in a peculiar manner for this purpose. It differs from the coke obtained from the gas-works in its great density, and beautifully silvery, glistening appearance. It presents, when well made, a very singular aspect, and more resembles a metal than a mineral. It is in this state so dense and hard that it may even be used to cut glass with, as a substitute for the glazier's diamond. And in some large establishments an attempt to use it for this purpose has actually been made. It endures an intense heat, without alteration of its characters; and when fully ignited, and the fire urged by a blast of air, it affords a sphere of combustion capable of reducing most of the metals to a liquid state in a short time. Coke in this condition bears some analogy to the diamond.

The subject of fuel is of such immense industrial importance, that it is scarcely possible to give it the prominence necessary for its proper elucidation in the space here devoted to it. It is necessary, however, to make some allusion to what is generally called artificial fuel. This term might convey an incorrect signification, and it is therefore necessary to state that it is intended to designate those artificial combinations of waste coal, turf, &c., which are devised with a view to give value to what would otherwise prove worthless substances. Of these some of the most remarkable specimens are the following. A patent process exists, by which the small coal which is generally wasted or sold at a loss, and near the coal mines is often actually permitted to burn away, or is used to form roads, or in some instances is thrown into the sea, is reduced to a solid block by pressure only. For this purpose, the dust is placed in a mould, and hydraulic pressure is made to act upon it so as to subject it to a weight of several hundred tons. The effect of this is to reduce it to a smooth polished and hard block, almost resembling a natural block of coal in appearance. Other processes are in use in which the waste coal is mixed up with a small quantity of bituminous matter, and then subjected to pressure. By a third method the waste coal is reduced to a solid block by the binding action of a cement. For some purposes these artificial fuels are considered to possess qualities better adapting them for use than natural coals; but it does not appear that they are largely employed. In other countries where coal is much more valuable than in Great Britain, the adoption of some of the methods of redeeming the inevitable waste arising from the small coal might perhaps be attended with benefit and economy.

Fuel is to industry, both the developing agency and the sustaining power. It is for this reason that the first place has been given to it in the present chapter, for it has been felt that too much importance can scarcely attach to that part of a subject upon which all the rest are more or less dependent. Let it be supposed for a moment, what would result in the absence or extreme scarcity of fuel in any country otherwise well adapted to become a manufacturing district. No kind of mechanical industry could prosper in such a condition of things; and upon mechanical industry the greatness of a nation is in the present day chiefly dependent. Fuel is the source of motive power, and it is even more than this, for a large number of manufactures could not be prosecuted without its assistance. The production of iron, glass, pottery, chemicals, must immediately cease on the cessation of a supply of fuel, and it requires but a little consideration to show the results to commercial enterprise of the stoppage of such manufactures as these. Such are the reasons which have induced us to place fuel at the threshold of a part of our work which proposes to deal with manufactures and arts; for of all raw materials that must be admitted to be the most important which is itself a source of power, and of heat. By the force of electro-magnetism we might produce sufficient power to drive machinery, or by the motion of the wind, or the pressure of water engines might be made, which would be even economical substitutes for the steam-engines; but we cannot conceive of a substitute for fuel as a source of heat; and to be able to produce heat at will, is to possess a fund of power, the direction and distribution of which is almost unlimited.

The metals and their ores, which from the industrial materials of the next importance after fuel might be here appropriately discussed; but it will be more convenient to defer so doing until a future opportunity. We shall proceed therefore to discuss the mineral materials used for the purposes of construction, such as stones and slates, and it will doubtless be found that there is instruction to be derived, even from such unpromising materials as these. A very interesting collection of these materials was shown outside the Exhibition building at its western entrance. The granites must be considered to hold an important position among the massive minerals used for purposes of construction.

The annexed engraving represents a large column of this material, consisting of a single block of granite. This column, which is of the Doric order, was about 30 feet high, and might be regarded as a trophy of the art of quarrying, as the difficulties attendant upon its extraction and sculpturing into form must necessarily have been considerable. The material was obtained from the Cheese-wring quarries in Cornwall. These quarries have not hitherto been largely worked, but they yield a fine-grained and most excellent stone. The quarries belong to the Prince of Wales. The size of the masses of stone which can be extracted from them, may be estimated from that of the shaft, which was a solid block 20 feet in length. This was not the only specimen of Cornish granite of a large



BLOCK OF CORNISH GRANITE.

size. A rough pyramid, which with its base was about 20 feet high, was also exhibited. It was taken from the quarries near Penrhyn, in Cornwall. This granite was largely used in the construction of London Bridge. From quarries in this district the principal portion of the granites used for public works has been derived, the annual export varying according to the demand from 5000 to 20,000 tons. The quarries of the Duke of Somerset at the Haytor rocks, in South Devon, also yield a valuable granite used for London Bridge, the Fishmongers' Hall, &c. The other localities from whence granites used for construction are principally derived, are Aberdeen, Peterhead, Stirling Hill, Dalkey in Ireland, and extensive quarries in the Channel Isles, especially in Guernsey, and the little island of

Herm, immediately opposite to it. The granites from the latter sources are principally used for macadamising roads. A very fine and excellent granite was sent for exhibition from Sweden. This was in the form of a colossal cross cut out of a single block. The stone was obtained from quarries at Uddewalla, in Sweden; it was remarkably fine grained, and almost resembled free-stone. It was of a pale buff colour.

The principal value of granite consists in its immense resistance to pressure, and its duration even when exposed to the most destructive influences. For these qualities it was valued by the architects of other times. The vast works of the Egyptians in this material are subjects of familiar knowledge. How insignificant the blocks above mentioned in comparison of one of the obelisks of Egypt, the height of which was about 84 feet, and the weight not less than 300 tons. This obelisk is now in existence in the piazza of St. Peter's at Rome, and is considered to form one of the largest specimens of a single mass of granite applied to the purposes of art, with the exception of the colossal statue of Peter the Great at St. Petersburg. It is stated—with what truth does not certainly appear—that the ancient Egyptians carved an entire edifice out of solid granite, and transported it by sea. The quality of the granite obtained anciently from Egypt was excellent; and specimens exist to this day which, although wrought into form two or three thousand years ago, still preserve uninjured the minute traces of the workman's tools. It must not, however, be forgotten that the climate of Egypt is one which does not rapidly affect materials exposed to its influence. The use of granite in England is limited by its costliness, and the difficulty with which it is worked. It may be remarked also, that the disposition of modern architecture is opposed to the construction of public works, calculated to endure for many centuries. This is a remarkable and suggestive fact, and it may have a meaning to which it were well to take heed. The architecture of the present day may be thus ephemeral in its character and operations, from a dim perception of the great truth, that in a little while will be realized the solemn truth, that all these things shall be dissolved, and every elementary creation destroyed by fire. Granite consists of a combination, apparently once fused by heat, of quarry, mica, and felspar.

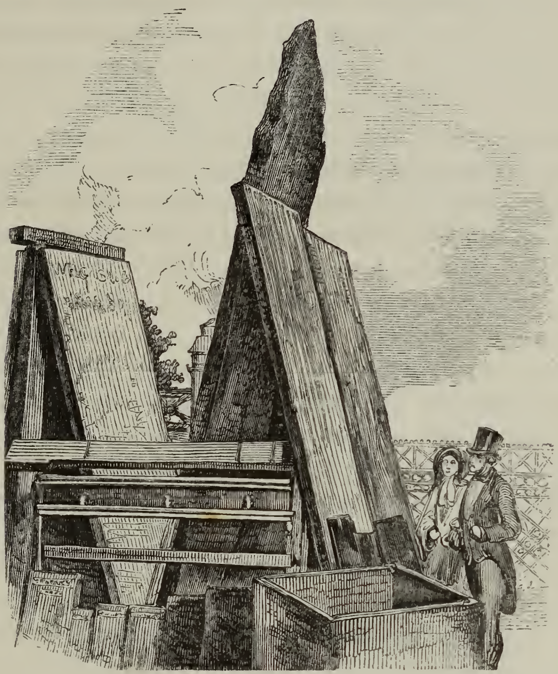
Of equal importance with granite, and of more general use are the limestones of various kinds for purposes of construction. Of these we shall only allude to the Portland stone, and to the Caen stone. The Portland stone quarries in the island of that name, yield several different kinds of stone suitable for different purposes. The best kind is obtained from the top bed, and is so fine and free from impurity, as to be adapted for ornamental architecture. The bed from which this stone is obtained is only about from 3 to 8 feet in thickness. The beds below it are of inferior quality, and are used for sinks, &c. This stone, which is annually quarried in large quantities, endures exposure to the atmosphere well, but it is costly in the first instance. It preserves a clean white appearance even in the smoke of the metropolis. It enters largely into the structure of many of the public buildings in London. It consists of carbonate of lime, with small proportions of silica and magnesia.

The Caen stone, obtained in large quantities and of the finest quality from the quarries at Allemagne, has been long worked, and is well known in all parts of England and France, being used in many of our cathedrals and other public buildings. The quarries are entered by narrow galleries opening from the steep banks of the river Orme, and thus have the advantage of direct water communication at very small cost.

The stone is soft in the quarry, of very beautiful rich cream colour and very even texture. It stands exposure well in France, but is better adapted for internal work in the climate of England. In illustration of the durable character of this celebrated stone, there were shown at the Exhibition of 1851, the following:—"Four specimens of ancient Caen stone, from St. Stephen's Chapel, Westminster, 16th century; St. Stephen's Church, Caen, 11th century; and Kingston Church, Sussex, 14th century; all in good preservation, and having apparently undergone little change from the time of their first exposure—in one of the instances named, the specimen being 800 years old."

The magnesian limestone used for purposes of construction, are those next in importance to the Portland and Caen stones. To this stone there is the interest attached which is derived from its having been used in the building of the new Houses of Parliament. The following remarks of Professor Ansted indicate the general qualities of this material. "The magnesian limestone used in the outside work of the Houses of Parliament was selected on the recommendation of a Royal Commission, and after careful examination, as the finest available material to be obtained. It is a compact semi-crystalline rock, consisting of nearly equal proportions of carbonate of lime and carbonate of magnesia. It is of uniform and elaborate hardness, not very costly, either to obtain or work; weathers well, and of good colour, and is remarkable for its power of resisting compression. It is much heavier than most limestones, weighing upwards of 150 pounds to the cubic foot."

The magnesian limestone in question was principally derived from the quarries at Anston, in Yorkshire, and large quantities were necessarily required for a structure so large as that just named. Other quarries yield a somewhat similar material. The debris of such quarries is often of value for the production of carbonic acid gas for manufacturing purposes. If decomposed by sulphuric acid, sulphates of magnesia and of lime are obtained. Of these the former, being soluble, is removed, and after proper purification, constitutes Epsom salts. The latter, sulphate of lime, is insoluble, and not of commercial importance.



SLABS OF SLATE.

Slates of various kinds must also be regarded as very important materials under this head. The above engraving represents a mass of slate of unusual dimensions, being about 15 feet in height, and of proportionate width, which was shown at the Exhibition. The most important sources of supply for slates, in the metropolis are the Welsh and Cornish quarries, and quarries in Lancashire and Westmoreland. The vast quarries in Caernarvonshire, near Bangor, have long been worked, and yield a large proportion of the slate used in various parts of the country. These quarries have as many as ten levels, and give employment to not fewer than two thousand persons. The slate is of excellent quality. In some quarries the material is cut, by means of ingeniously arranged mechanism, into the sizes for market. Some of the quarries in Argyleshire have been worked for upwards of three centuries, and export nearly ten millions of slates annually. The purposes to which this material is applicable are varied. Its most general use is for the roofs of houses. It is a somewhat singular fact that this method of roofing is characteristic of European habitations, and is not to be found in the houses of Asia, although the material exists in sufficient abundance. Slate is now largely used for other purposes than roofing. It is employed to a very important extent for the construction of cisterns, and receptacles for fluids of different kinds, as a substitute for lead. The perfect cleanliness and impenetrability of this material render it peculiarly suitable for such purposes. There is, however, some trifling difficulty in obtaining a water-tight joint for the necessary fittings. Slate is also used for various filters, which act in different ways in removing the impurities from water, for domestic purposes. The slate obtained from Valentia, in Ireland, offers a remarkable degree of resistance to pressure. On subjecting small cubes of this material, of about an inch square, to hydraulic pressure, it was found that a force of six tons required to be exerted before they could be crushed.

The following curious terms are applied by persons engaged in the sale of slates to the different sizes used for different purposes.

"The present consumption of slate in London," observes the authority before quoted, is "to the extent of from 30,000 to 40,000 tons per annum. One third of this quantity is in slabs, and the rest in roofing-slates, which are in nine sizes, called respectively 'ladies,' 'countesses' (3 sizes), 'duchesses' (2 sizes), 'queens,' 'rags,' and 'imperials.' From 'ladies' (16 inches by 8) to 'duchesses' (24 by 12), the slates are sold per thousand (of 1,200 slates), but above that size by the ton. The 'ladies' weigh 25 cwts. 1,200 slates, and the 'duchesses' 3 tons. The regular-sized slabs vary from 1 to 6 feet in length, and 1 to 3 feet in breadth. A large quantity of slate slabs is also used for ornamental purposes."

Sandstones, and freestones, are much employed for the purposes of construction in the immediate vicinity of the quarries, and to a large extent for paving and similar purposes. Some stones of this kind possess some singular properties. Among such may be reckoned that of the Binny quarry, in Scotland. This stone, which is used for building purposes, appears to be impregnated with bituminous matter, which acts as a protective varnish to the stone, and defends it from atmospheric influences. This bitumen is made by the workmen, when obtained in sufficient quantities, into candles, which are used by them for domestic purposes. The bitumen exudes from between the layers of the stone, whence it is collected by the quarry-man. Among materials of this class are to be reckoned the specimens of stones sent from Malta to the Great Exhibition, some of the sculptured portions of which were represented in a preceding page. The stone is called Malta stone, and is obtained from a thick series of beds which are largely quarried for the purposes of construction, not only in Malta, but in all parts of the Mediterranean. Some of the pieces exhibited were said to be oiled and prepared for pavement. The finer kinds of this stone are used for ornamental purposes, as jugs, vases, &c.

We shall conclude our notice of the massive minerals used for construction by a slight sketch of those employed for ornament. And these may be conveniently subdivided into ornamental minerals for the decoration of houses, &c., and those for personal ornament, as gems and precious stones. In the production and preparation of both of these classes of minerals an important department of industry is concerned.

Marble of various descriptions takes an important place among the minerals of the former class. A considerable quantity of marble for ornamental purposes is obtained from various quarries which are worked with more or less success in Ireland. The best varieties are the green and black, the former of these is extremely beautiful in its appearance, and would be well calculated for ornamental uses if the colour were durable, but unfortunately it does not endure prolonged exposure to the air. Quarries are also worked in the Isle of Man, which yield variegated marbles of differing degrees of excellence. The architect is, however, chiefly dependent for marble on the counties of Derbyshire and Devonshire. Large quantities are annually raised in these districts, and are used for chimney pieces, and other purposes of a similar kind. The black marble is the best of the varieties obtained.

This substance, which consists chemically of a crystalline carbonate of lime, is yielded of much finer quality and superior character by other countries than our own. For the finest description of marble, in fact, England is entirely dependent upon importations from abroad. The marble quarries of Tuscany have been worked for many centuries, and still yield important supplies of this material, of the finest kinds. Professor Corridi has given the following interesting account of these quarries.

"The quarries for statuary marble are very numerous; and those situated in the vicinity of Saravezza and Campiglia, in the Maremme, are the most ancient and the richest of all. The working of the quarries of Saravezza was completely interrupted towards the end of 1600, solely on account of the decline of the fine arts, although they had yielded a large amount of materials in the times of Michael Angelo and Cosmo I. But the works having been resumed with considerable energy in 1821, through the exertions of the present Grand Duke, Leopold II., and under the excellent management of M. Borrini, they soon reached the highly prosperous condition which they now enjoy. The pure and fine saccharoidal marble, from the mountains of Saravezza, is prized by sculptors, and is in great demand in England, France, Russia, and several other countries. The superiority of the produce of these quarries induced the Emperor of Russia to send a considerable order, now in progress of execution, amounting to upwards of one million of roubles, for the internal decoration of the new cathedral of St. Isaac, in St. Petersburg.

"Before the year 1821, the period to which we have alluded, the marble trade of Saravezza consisted merely in the manufacture of a few flooring-flags of common white and blue marbles, from the Cappella mountain, and some tables. The improvement which has taken place during the last twenty-five years is almost incredible. There is not a single marble quarry round Saravezza which is not excavated and furrowed everywhere. Children begin to work when nine years old, and easily earn their livelihood, and adults have a very profitable source of occupation. A small market-town has sprung up near the sea-shore, where the shipping of marbles takes place, and contains about five hundred people, while, before 1821, the solitary hut of a fisherman was the only edifice discernible on the spot. The natives have by degrees built and manned a small navy, to carry on a coasting trade between Genoa, Leghorn, and Marseilles."

The Italian marbles, and particularly those of Carrara, are held in the highest esteem. The marble quarries of this town have been wrought from before the age of Augustus. There are several kinds of Carrara marble in use. One of this is called the dove-coloured, and is suitable for architectural ornaments. These beds are distinct from those which yield the statuary marble. This beautiful material, which is in universal request for sculptors, is derived from other beds at a little distance up the valley in which the town is situated. About twelve hundred persons are occupied in these quarries, and a large export trade is carried on exclusively in marble. It has been said that so rare is it to meet with a block of pure white marble, that if obtained once out of every ten masses excavated, the quarrymen are satisfied with their success. The supply of this beautiful substance appears inexhaustible, but the demand is materially affected by its cost. Spain also possesses some valuable quarries of marble. Near Madrid, and at Saragossa, the most beautiful description of marbles, of a delicately shaded and variegated character, are obtained. The quarries of Greece supplied the ancients with the finest marbles, both for sculpture and ornament. They are very extensive, and under the auspices of the Greek government many which had been neglected for ages have been reopened. Marble of every variety of colour is obtained from them. Many specimens of these were exhibited at the industrial concourse of 1851. The description attached to one or two of these will be considered interesting by those who hold classical associations in estimation.

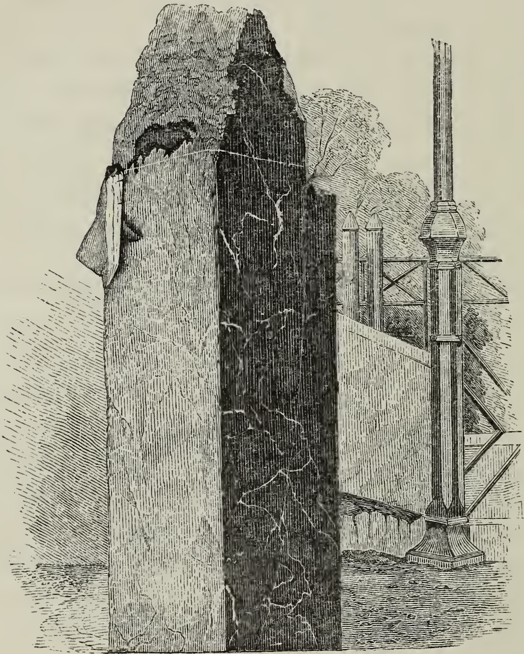
"The marble cipollino of Karystos is found in the old quarry Marmaria, near the village called Styra, or, as Strabo says, 'Near there is seen Styra and Marmaria, whence are quarried the columns of Karystos.' Situated in this quarry are still to be seen half-worked columns, and from this quarry the large pillars of the temple of Anthony and Fausta in Rome, as also other pillars, of one single piece, lying in the Court of Innocents, were excavated.

"One piece of white marble, from Pentalicon. This is the same kind of marble as that of which the Parthenon and other monuments in Athens were built, as well as many statues made; and since Athens became the capital of the new kingdom of Greece, this marble has been used in building many of the public edifices and private houses.

"Two pieces of marble from Paros, called Lichnites by the ancient Greeks. This marble is very transparent and brilliant, very white and fine-grained.

"The Lichnite marble of Paros is very white, transparent, finely granulated, and of a crystalline appearance; of which Strabo says, 'The Parian stone is excellent for statuary;' and Pindar says, 'We erected a column of Paros stone.' The ancient quarries from which the sample has been taken are very deep. The ancients were obliged to make use of a lamp during the excavations, and some think that it derives its name from that circumstance; and others account for it by the transparent and bright nature of the marble."

A very interesting material, applied somewhat in the same way as marble for ornamental uses, has come into much prominence of late. This is serpentine, of which a beautiful block, polished to show its rich veining, is represented in the annexed cut. This material is principally obtained from near the Lizard point, in Cornwall. It has become of so much importance that a company has been formed to work the quarries there. The predominant colour is a rich reddish brown, veined with white streaks, which are due to thin portions of soap-stone, or steatite. Serpentine consists principally of a silicate of magnesia, with certain colouring matters. A letter has been published from an exhibitor of objects made of this substance, at the Great Exhibition, which conveys an interesting view of the present state of the



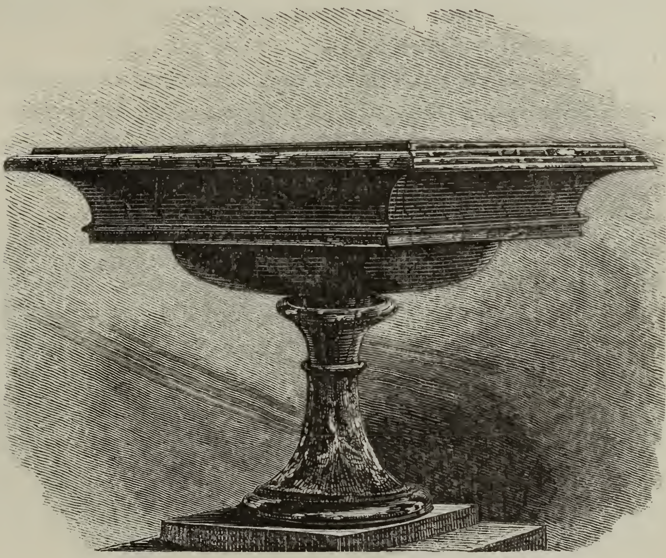
BLOCK OF SERPENTINE.

quarries in Cornwall. This we shall extract from the pages of Mr. Hunt's Handbook to the Great Exhibition.

"The extent of the quarries that we are now working is about one mile on the face of the cliffs. Our quarry for green and green and red serpentine is about three quarters of a mile east of the Lizard lighthouse, and for the red serpentine is three miles east of the light on the eastern side of Kenneck beach.

"The largest block of good serpentine which we have yet got out was 8 feet long, 3 feet wide, and $2\frac{1}{2}$ feet thick, of superior quality. In order to get this block we have quarried some hundreds of tons, out of which we have about 120 tons, small and large, fit for work. We clear away from the top of the cliff, until we get a floor down on the serpentine, or reach a lode, and then we throw the blocks out at the joints, and slide them carefully down the cliff, ready to remove by waggons, if of large size ; if small, we remove them in barges to the works, when the sea is smooth.

"We have almost endless varieties ; not two slabs alike, even of the same block. The red varieties are the largest blocks, mixed with steatite veins. The red and green varieties run small. It is very seldom that we can get the blocks more than from 2 feet to 3 feet long ; and we have to quarry large quantities to get a small lot of this fit for working purposes. The steatite runs in small narrow veins, seldom 1 foot wide, and when of that size always mixed with serpentine."

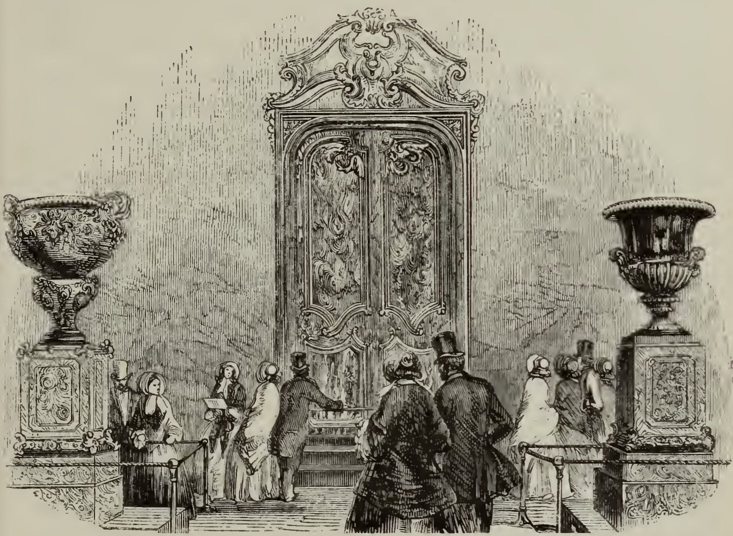


VASE OF JASPER.

The above cut represents a vase sent to England from Russia for exhibition, which illustrates another mineral material of more limited application than marble, but of considerable beauty and value — jasper. This vase is of immense value ; not so much from the character of the material itself, as from the amount of labour necessary for its reduction to shape, since it is extremely dense and hard. The manufacture of ornamental objects from this and similar materials has been long established in some parts of Russia. The jaspers are generally obtained from the Ural mountains. Several vases were sent from the imperial works at Kolyvan, in the government of Tomsk. One of these was of a greenish hue, another was of a violet, or amethystine, colour. In the travels of M. Erman an interesting view of this department of Russian industry is given, of which we here present an abstract. These quarries are carried forward on the bank of the river Tret, by the Russian Government. Large columns, capitals, and vases, are produced at these works. The machinery used is set in motion by a powerful water-wheel driven by the Tret.

All sorts of figures in relief, curvilinear ornaments, and foliage, are carved with as much ease, by gravers, revolving on axes, as simple cylindrical surfaces have been turned heretofore. The mechanism of the lathe has been so ingeniously and effectively applied to the operations of the graver, that the cutting disc in which it terminates is rendered instantaneously available for every form of arrangement of ornamental carved work. A number of these lathes, fixed in different parts of an extensive building, are set in motion at once. The metal discs used in dividing the blocks of stone, in the first instance, derive their motion from the same power; as do also the several pieces of jasper in process of manufacture at times when the operations of cutting and polishing their surfaces require it. Copper, and even leaden discs, are indispensable in working the hardest stones; and it is only for economy that iron is used at all; for the softer the metal, the more rapid is the action of the emery powder with which it is covered. By this application of machinery to the instruments used in cutting and polishing, not only is a very considerable economization of time effected, but the saving in the expense of labour amounts to 8,000 roubles yearly; while some operations that were before impossible are now easily performed. The size of the objects to be produced was formerly limited by the natural strength of the artist; whereas works of colossal dimensions, which it was heretofore only possible to accomplish by uniting a number of pieces, are now completed in a single block of the material.

Another beautiful mineral material, though belonging to a very different class to the last, is malachite. Until of late this substance was only known in England in its application to minute objects, being almost regarded as a precious stone. But malachite, since the Exhibition, has assumed a very different aspect,



OBJECTS IN MALACHITE.

for none who visited it can forget the gorgeous articles of furniture made of this material. The splendid doors and vases represented in the cut, were only a part of a suite of furniture of the most beautiful and costly character, and of a kind that was probably never before shown in England. The malachite doors are thus described by Professor Ansted, in the notes to the Official Catalogue.

"The magnificent works executed in malachite, and exhibited by the Messrs. Demidoff, the proprietors of the principal mine and manufactory of the stone, far surpass in magnitude and excellence the finest that had before been seen out of Russia. The best and most costly of the objects exhibited is the pair of doors, measuring 14 feet 5 inches high, and 7 feet wide. They are built upon a framework of metal, the malachite being veneered in thin slices about a quarter of an inch thick. But the chief peculiarity of the manufacture consists in the ingenious way in which the cut pieces of stone are adapted to each other so as to form a pleasing and appropriate pattern, and cemented by a very coarse cement made of fragments of the stone itself, and coloured in the same way. The magnitude of each piece of malachite is very inconsiderable, any single object being made up of hundreds, or even thousands of pieces, cut into a fit shape. In this way a large proportion of the whole is absolutely lost; and as the finer pieces are of considerable value, the cost of material is thus very considerable in addition to the great labour. Some idea may be formed of the latter, when it is stated that in addition to the labour of cutting and partly fitting the pieces, it occupied as many persons as could be employed on the doors (thirty men) a full year to fit, finish, and polish them. The total quantity of labour employed was, however, much greater than would thus appear, since the work went on day and night without ceasing during the whole time, from the 1st May, 1850, to the beginning of May this year, 1851. The vases and chimneypiece of the same manufacture are hardly less valuable and magnificent."

These mines are a source of immense wealth to their proprietors, who are also owners of extensive sources of platinum and gold. The value of the doors in question was upwards of 6000*l.* for the pair. The value of one of the vases was 3,200*l.*, of another 2,400*l.*, and of the chimney-piece 1,600*l.* A writing-table of an oval form, 3 feet in length, and 2½ wide, was valued at 400*l.* It may truly be said that such furniture became only the apartments of a palatial residence.

Among mineral substances upon which productive industry is occupied for the manufacture of articles of ornament, plumbago can scarcely be said to hold a place; yet it will be convenient to make some short observations on this singular and valuable mineral in this place, since it might not be possible to do so appropriately in any other. Plumbago consists chemically of carbon, with variable quantities of impurities in the form of silica, and oxide of iron. It is improperly, therefore, called black-lead, — pure plumbago being merely one of the forms assumed by the familiar but remarkable element, carbon. The best material is obtained from the long worked and, apparently, nearly exhausted mines of Borrowdale in Cumberland. About fifty years ago, a large lump was suddenly encountered, which yielded 70,000 pounds weight of this precious material, of the value of 30*s.* a pound. But since then little has been met with, and that in such small pieces, that a mechanical process of great ingenuity was invented to reduce these pieces to a solid mass, available for the pencil-maker. This is effected in the following manner. The process was patented by its inventor, Mr. Brockedon, who has given the following description of his method of condensing the material.

" Carefully-selected pieces of any size are ground in water, by an arrangement of rollers, to a most impalpable powder. This occupies a considerable time. This powder is then passed through sieves, the meshes of which are the smallest that can be made, as it is of the utmost importance that the particles should possess perfect uniformity. This prepared plumbago is now made up into small packets in paper contrived for the purpose, with a small hole upon one side, on which is fitted an adhesive wafer which acts as a valve. This is necessary, as previously to submitting the pulverulent mass to pressure, it is necessary that all the air which occupies the spaces between the particles should be removed. This is done by connecting each packet, by an elastic tube, with the exhausted receiver of a powerful air-pump. On opening the connection between them, the air is entirely withdrawn, and as soon as the force is removed, the little valve closes by the external pressure of the atmosphere, and the packet is fit for compression.

"The square mass of powdered plumbago is now carefully fitted to a steel mould, into which a plug of steel exactly fits; it is then subjected to the action of an enormous screw-press, from which it receives two blows, giving a pressure equal to 5,000 tons. A solid mass thus results, which can be cut into any thickness by the pencil-maker; every part of each mass being of exactly the same quality. Close examination shows that the particles have arranged themselves under the influence of the pressure in precisely the same manner as in the natural productions; and if one of these compressed masses is broken, the fracture is exactly similar to that exhibited by a piece of native plumbago."

Plumbago is obtained in a remarkably pure form in Ceylon; and is also imported from Davis's Straits, Spain, Bohemia, Greenland, California, France, and India. The Cumberland lead, however, continues to retain its superiority. Lead pencils are made by placing thin slices of plumbago in a groove cut in a piece of cedar, over which another piece is then glued, and the whole cut into a cylindrical form in a lathe.

The element, carbon, has already been extensively under notice in the present chapter. In the form of wood, peat, lignite, coal, coke, and plumbago, it has been seen that its relation to the varied industrial occupations and necessities of mankind is apparently superior to that of any other substance whatever. It must again appear before us in a shape, perhaps, the most remarkable and mysterious of all—in our short considerations of the mineral substances or materials employed for personal ornament—namely in that of the diamond. The origin of this gem is involved in great obscurity; for while it has been satisfactorily shown that it consists of nothing more than carbon in its purest form, it has never yet been proved how the crystals originated. One of the most probable suppositions, as it appears to us, is, that this gem is the result of an extremely slow crystallization from a liquid form. It is doubtful whether a great heat was essential to its production—probably it was not.

The countries in which the diamond has yet been discovered are far from numerous, the only localities in which it is found being the Indian peninsula, Brazil, the island of Borneo, and Siberia, on the western side of the Ural mountains. It is generally found among diluvial gravel and conglomerate rocks or pudding-stone, consisting chiefly of rolled flint pebbles and ferruginous sand. India has from the most remote ages been celebrated for the beauty and magnitude of its diamonds, the largest and most valuable of which, it is familiarly known, are obtained from the mines in the provinces of Golconda and Visapoor. The tract of country producing these gems extends from Cape Comorin to Bengal, and lies at the foot of a chain of mountains called the Orixa, which appear to belong to the trap-rock formation. The diamonds obtained from the richest localities are rarely procured by directly searching the strata in which they are found, since they are commonly so coated with an earthy crust on the outside, as not to be readily distinguishable from the various other substances with which they are associated. For this reason the stony matter is first broken into fragments, and then washed in basins for the purpose of separating the loose earth; after which the residual gravel is spread out on a level piece of ground, where it is allowed to dry, and the diamonds are recognized from their sparkling in the sun.

There are several varieties in the colours of this precious gem, which greatly differ from each other. In the Great Exhibition these were well illustrated, and among its many objects of wonder and attraction were splendid specimens of diamonds of all known varieties. Among the more interesting was a magnificent blue diamond exhibited by Mr. Hope, and an immense black diamond from Bahia. It is unnecessary to enter into detail on the subject of the various weights of fine specimens of this gem; the following notes may, however, be useful. The Great Mogul diamond is said to have weighed in the rough state 900 carats, the Russian diamond weighed 195 carats, the Pitt diamond 136 carats, and the Nizam diamond about 138 carats. The history of the latter gem has been thus told in a catalogue sent from India to the Exhibition accompanying a model of this gem.

It was first seen in the hands of a native child, who was playing with it in ignorance of its value. The sum of 8 "annas" having been offered for it excited the suspicion of the parents of the child, and led ultimately to the discovery that the bright stone was a real diamond. The diamond, after having passed through many hands, was purchased by a native banker for

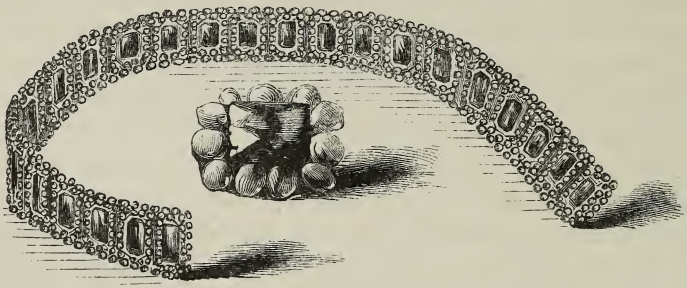
70,000 rupees, and it is now in possession of his Highness the Nizam. The stone is of an irregular oval shape; its length is 2·48, its greatest breadth 1·35, and its average thickness 0·92 inches. The actual weight of the Nizam diamond is 1,108 grains, being equal to 277 carats of weight for the rough diamond; and as the rough stones are usually taken to give but one-half of their weight when cut and polished, we should have 138½ carats, or a weight between the Pitt or Regent diamond (136¾ carats), and that of the Grand Duke of Tuscany (139 carats) as the weight of the Nizam diamond.

We are not informed if this stone is considered as likely to be one of pure water, which can only be ascertained by polishing it, but the natives of India, and particularly of the Deccan, are too good judges of diamonds to mistake a topaz for one, and it is stated that 70,000 rupees have been paid for the fragment. It therefore certainly adds one extraordinary fact more to the history of this most wonderful of the gems.

The great diamond, the property of Her Majesty the Queen of England, the Koh-i-noor, or mountain of light, has also a very singular story. According to Hindu legend, it was found in the mines of the south of India, in the days of the great war, (the subject of the heroic poem, or "Mahabharata,") and was worn by one of the warriors who was slain on that occasion, Karna, king of Anga: this would place it about 5,000 years ago, or 3001 B.C. A long interval next makes it the property of Vikramaditya, the Rajah of Ujayin, 56 B.C., from whom it descended to his successors, the Rajahs of Malwa, until the principality was subverted by Mohammedan conquerors, into whose hands it fell with other spoils of infinite value.

Ultimately it became the property of Runjit Sing, and on the annexation of the Punjáb by the British

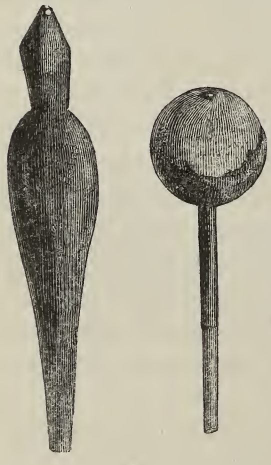
Government, it was given up to its present Royal Possessor. The gem, with two others of smaller size, which formed its setting, was exhibited at the Great Exhibition under protection of an iron grating, and formed an object of great attraction to hundreds of thousands of visitors. Another great diamond was exhibited by the East India Company, called the Sea



THE SEA OF LIGHT, AND EMERALDS.

of Light. This gem is shown in the cut, with a splendid girdle of emeralds. The presumed value of the Koh-i-noor is 2,000,000 sterling, but its actual worth is, without doubt, greatly under this sum.

The annexed engraving represents the manner in which diamonds are cut. The two sticks represented show the method of fixing the diamond while subjecting it to the process of polishing. Two diamonds are first placed at the end of a stick, and secured there with cement. They are then rubbed against each other by the workman, until wrought into form. A small quantity of powder falls in this process, and is carefully preserved, for cutting and polishing. The polishing is effected by sticking the diamond in a



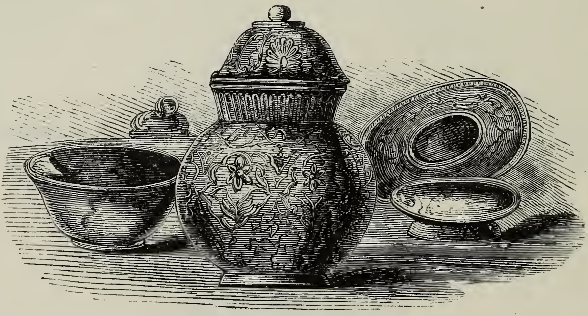
piece of lead at the end of a tool, and it is presented facet by facet to the action of a circular plate of iron charged with oil and diamond powder. The whole operation is extremely tedious and difficult in consequence of the intense hardness of the gem. It may serve to correct a popular error, to mention in this place, that the powder sold under the name of diamond powder, is not in reality any such substance, consisting merely of powder of emery. True diamond powder is far too precious to be thus retailed. Diamonds are also cut by a fine wire besmeared with diamond powder.

The remarkable specimen of quartz which was shown in the near vicinity of the great diamond at the Exhibition, and which is represented in the annexed cut, deserves mention here. This large and interest-

MASS OF ROCK CRYSTAL.

ing crystal consists entirely of silicic acid. In the instance in question it was free from colouring matter, but it is very frequently found coloured by various metallic oxides. In Scotland ornaments are, to a very large extent, manufactured out of coloured specimens of quartz, called Cairngorms.

The Cairngorm mountain, forms one of the Grampians, and rises to the height of 4,080 feet. It is well known, and has been long celebrated for the fine quartz crystals of white, pink, dark brown, and black varieties which take their name from it, and are found either in the cavities in the rock or the debris of rivers. Of these crystals, the deep-yellow varieties, when well cut and set, are sold as topazes, and sometimes called Scotch topaz.

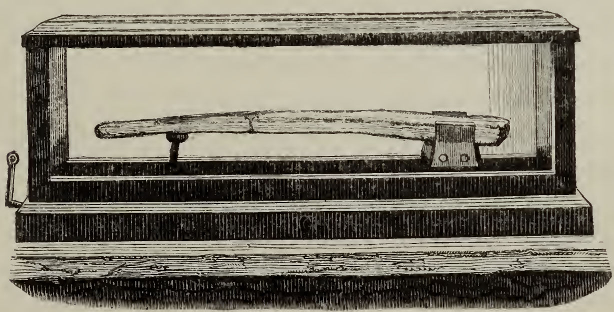


OBJECTS IN ROCK CRYSTAL.

In India the pure quartz is cut into various ornaments which are as pellucid as frozen water. Of these, some are represented in the cut, and form part of the splendid collection of such objects preserved by the Hon. East India Company. The jug, basin, and other ornaments are of so perfect a purity as to be comparable to nothing more closely than to the appearance of ice. The same substance is also used for spectacles. The terms onyx, sardonyx and chrysoprase of Scripture, introduced by the inspired writer into his glowing description of the city of God, as applied to precious stones, represent varieties of quartz coloured in different ways.

The magnificent girdle of emeralds preserved by this Company is perhaps quite unique. Some beautiful crystals of this gem are sometimes found. There exists a mine in New Granada which yields good specimens. Among other precious stones of great value, the ruby, topaz, opal, and beryl take a prominent place; garnets are also important as contributing to the industrial activity of the peasants in certain parts of Germany and elsewhere. Many of these precious stones are of a certain value in the mechanical arts, in addition to their use for the purpose of the jeweller. The harder kinds are employed as the bearings of the delicate axes in watch-work, and endure the constant friction thus imposed upon them with scarcely any sensible abrasion. The diamond, however, true to the characteristics of the element composing it, as most importantly contributing to the advancement of industry, surpasses the whole in its direct utility, of which a familiar example is afforded by the cutting-tool of the glazier. Sometimes the optician has used diamonds for lenses in microscopes, but the vast labour of grinding them, coupled with their cost, has prevented their extensive employment. The handle of Murat's sword was of a single beryl; two emeralds united, and carefully cut, have formed a *vinaigrette*, but beyond these and similar applications, the uses of these precious and beautiful substances must be acknowledged to be extremely limited.

Among the mineral curiosities contained in the

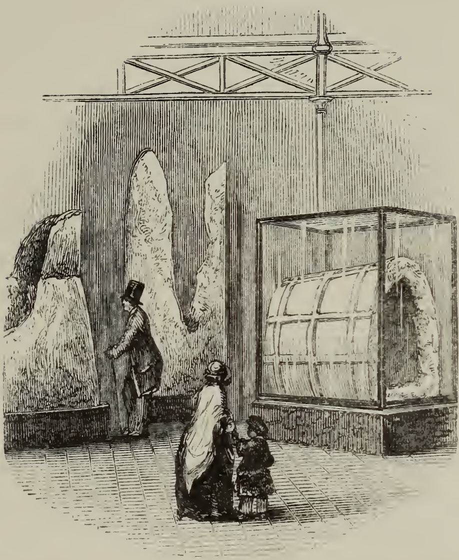


SLAB OF FLEXIBLE STONE.

Great Exhibition, attention was excited by a small specimen of flexible stone, arranged in a little case, so that in touching a handle its elastic properties could be displayed. This is shown in the cut. Such a material has not as yet been applied to any industrial purpose. It would appear that the mineral mass from which the specimen was taken has been permeated by bituminous matter, which gives elasticity to it.

It appears undesirable to extend the limits of the present chapter by adverting to the mineral substances used in the arts, as these will be sufficiently adverted to in their proper places. A brief review of the contents of this chapter will show how important to man are those substances, which often present themselves in the character of the most familiar objects, as in that of the slates which protect our dwellings, or the stone which contributes to its construction. Nothing, in short, is unimportant, upon which human labour is always occupied. Although it is our natural tendency to give value to things beautiful and rare, the reflecting mind will soon discover that in reality these are the less valuable objects, while the more common ones are those of the chiefest importance. Regarded in this light, the mines of Golconda are but a poor possession in comparison with those of Newcastle. The first contribute very occasionally to the enrichment of one or two individuals; the last give constant occupation to thousands, and afford, indirectly, power and wealth to thousands more.

CHAPTER XII.



MATERIALS OF INDUSTRY.—CHEMICAL SUBSTANCES.*

THE application of the science of Chemistry to the pursuits of manufacturing and commercial industry is very recent. The processes of various manufactories have been for centuries conducted by certain rules based upon experience, and to which philosophy contributed little or nothing. Satisfied with the constant attainment of a sufficiently remunerative result, the manufacturer appears scarcely to have dreamed of

* The cut represents the chemical trophy in the western avenue of the Exhibition.

calling in science to his assistance. Yet a very little consideration will show that an acquaintance with the principles of philosophic chemistry would have yielded most valuable information of a practical kind, had it been applied to those parts of a manufacture which are essentially chemical. That engineer who was ignorant of the mechanical powers of the lever, wedge, and pulley, could not be expected to construct a very efficient, much less an economically-acting machine. Yet the chemical manufacturer, and others in whose arts chemistry fulfilled an important part, were for a long time ignorant of the true principles of combination and decomposition, and, following in the steps of their predecessors, appeared content with their limited success. The most simple and familiar illustration of the effect of this ignorance is to be obtained from reflecting on that law of the atomic theory which defines the proportions in which bodies unite with each other. By this law it is most plainly proved that chemical substances unite with each other to form compound bodies in definite proportions; thus, it may be that three parts of *a* will always unite with one of *b*, never with more or less in that particular substance. Let us say that *a* and *b* united will form Epsom salts,—although for that substance the proportions named are not correct;—if therefore the manufacturer wishes to make this substance, he will first weigh out three parts of *a*, and next one of *b*, and will mix them together. If he does so, there is no loss of material; the proportions are such as exactly to neutralize each other, neither more nor less. But if in his ignorance he weighed out six parts of *a* to only one of *b*, he would actually waste three parts of *a*, simply because there was not enough of *b* to neutralize it. In this we are presented with a faithful picture of what was at one time constantly occurring in other manufactures than that of the substance alluded to. Manufacturers were continually incurring a direct waste, arising from their ignorance of the proper proportions in which they should have united the various substances they employed. This is not the case at present, and chemistry contributes, perhaps, more than any other system of philosophy whatever, to the advancement and perfection of the industrial arts of the present century.

The subject of the present chapter will be a short review of those substances which are prepared by the manufacturing chemist for use in the various arts and manufactures. To these it will be necessary principally to confine the attention of the reader, since it would otherwise be necessary to advert to a vast number of bodies which have little or no general interest, however attractive to those engaged in this pleasing study.

Modern science has pressed into the service of the manufacturer so many substances of a chemical nature that it is somewhat difficult to make a right selection of the most important. Too much prominence can, however, scarcely be given to the two classes commonly called alkalies and acids; and out of these we shall now proceed to make choice of one or two instances. The alkali soda may be very safely put in the first rank of extensively employed, and exceedingly valuable chemical substances. The production of this body, which is an oxide of the metallic element sodium, forms at the present time the occupation, almost exclusively, of immense factories. But it was formerly obtained in very different quantities, and by a very opposite method to that now employed. It is very generally known that all plants contain, in addition to their organized tissues and secreted products, certain mineral substances and alkalies among them, which are necessary to their well-being. The land plants contain more potash than soda; the marine plants more soda than potash. These substances not being volatile but fixed, and consequently not undergoing combustion, when the plants are burned, may be obtained in their ashes. And such for a prolonged period was the source of the soda of commerce. It was derived from the ashes of marine plants. These plants were collected in immense quantities along the Northern coast, and after being dried were incinerated in heaps, and the ashes carefully gathered up. These being steeped in water, yielded to it their soluble constituents, among which was a considerable proportion of soda; and this, after various processes, was separated in a tolerably pure condition, and sent to market. The busy scene presented during the collection and burning of the seaweed along the romantic coasts on which it was carried on, is now seldom to be witnessed. The burning of kelp, as the process was called, has been almost wholly superseded by the improved method of obtaining the alkali; and a large extent of what was formerly valuable property, is now almost without value. Kelp yielded, in addition, other chemical products, such as iodine and bromine, in minute quantities, which are not of course obtained in the other method of manufacturing soda, which we shall now describe.

Common salt consists, as is very generally known, of two elementary substances. Chlorine, which is gaseous, and sodium, which is metallic; being in fact a chloride of sodium. It has already been mentioned that soda is a compound of oxygen with sodium. In common salt the sodium is the valuable ingredient for the purposes of the manufacturer of alkali, and all his processes are directed to its separation and extraction in a form suitable to his purposes. But in order to effect this, it is necessary to decompose the salt, and thus to induce the sodium to part from the chlorine, and to unite itself with another element. The manner in which this is effected is as follows. It has been found that by pouring sulphuric acid upon common salt, with the assistance of a high temperature, the salt is decomposed, and becomes sulphate of soda —the chlorine which it contained being given off in the form of a gas united with hydrogen, and thus constituting hydrochloric acid vapour. This decomposition is first in the series.

Furnaces of a peculiar description are employed in the conversion of chloride of sodium (common salt) into sulphate of soda, by means of sulphuric acid. These furnaces are called reverberatory, because the heat they communicate to the substances placed in them is not applied to these substances immediately, but is reflected down upon them from the arched roof, along which the flame passes. In one compartment of such a furnace the common salt is placed, and immediately above it is an opening through which sulphuric acid may be poured upon it. The decomposition is gradually effected throughout the whole mass, the acid dropping upon it, uniting with it in successive portions until the whole is converted into sulphate of soda. In order to facilitate the union, and to render it more complete, the mass which assumes a viscid condition is stirred about with a rake covered with sheet lead, that metal being only slightly acted on by the sulphuric acid. This mass is subsequently calcined, and thoroughly dried in another reverberatory furnace, or in a separate compartment of the same.

This is the first stage in the decompositions, and a mass of sulphate of soda, with some impurities, is now in the operator's hands. The chlorine of the common salt, uniting as before mentioned with hydrogen, escapes as hydrochloric acid vapour. This acid vapour is a source of some trouble to the manufacturer, and was formerly a cause of enormous expense, in the construction of immensely high chimneys intended to dissipate it in the atmosphere. It is now generally condensed in the following manner: the vapour is led from the decomposing furnace into a vertical flue filled with masses of coke or sandstone, down which a stream of water is constantly trickling. The water immediately absorbs all the acid vapour, and falling to the bottom is obtained as a dilute hydrochloric acid. This can then be concentrated by distillation, and is of some commercial value, although scarcely sufficient to render the operation of its extraction from the air of the furnaces an economical process.

The next step in the manufacture of soda is to decompose the sulphate. The sulphate of soda is then mixed with chalk and small coals, and is decomposed by heat. The decomposition which it is intended to effect, is first to decompose the sulphuric acid of the sulphate of soda, so as to convert the latter into a sulphuret of sodium. This is accomplished by means of the combustible matter of the mass, aided by the heat to which it is exposed. The next change is to remove the sulphur from the sodium, and unite it with the lime of the chalk, so as to form a sulphuret of calcium; while at the same time the oxygen of the lime unites with the sodium, forming soda, and this again with the carbonic acid of the lime, so as to form carbonate of soda.

Such a change is effected in the furnace; and by this means the manufacturer has at length at his disposal, the soda, the metallic element of which in a combined state he possessed in common salt or chloride of sodium. The methods by which the decompositions referred to are developed on the large scale, are very simple, apparently, in operation, but are found to require skilled and careful labourers to prevent loss and waste.

It is conducted practically in the following manner. The sulphate of soda, technically called in that state, saltcake, is mixed with certain quantities of small coal and chalk, and is then placed in a reverberatory furnace. Here it is subjected to a red heat, when it begins to melt, and is repeatedly stirred about by long iron rakes. Decomposition then takes place; the whole mass is illuminated by jets of gas, which burst from it and take fire, giving it a beautiful appearance; and after some further continuance of the heat, the entire combination of the materials has been effected, and the whole is withdrawn from the furnace. The mass is now quite black, but contains carbonate of soda, a little caustic soda, some undecomposed sulphate of soda, and carbonaceous matters, lime, and sulphuret of calcium. In order to separate the carbonate of soda from these, the black mass is put into vats, and there allowed to remain until all the soluble matters have been removed from it by warm water. The water removes the carbonate of soda, with the small quantities of caustic soda, and sulphate of soda. These are decomposed by evaporating the solution to dryness, and heating the mass with sawdust in a reverberatory furnace. In the state as thus obtained, the carbonate of soda is sufficiently pure to render it available for most commercial purposes. A purer kind is, however, got for chemists and more delicate processes, by recrystallizing the soda in immense pans.

Such is a brief outline of one of the most remarkable and extensively pursued processes of manufacturing chemistry. The inventor of this process was a Frenchman of the name of Leblanc; and it deserves notice, that the process is due to the presence of a national necessity experienced by the French, at a time when all their usual supplies of soda were stopped by war. At the present time immense factories exist in the north of England and in Scotland, at which soda is produced in enormous quantities. So extensive in fact are these operations, that it is found absolutely necessary to manufacture the sulphuric acid employed, on a very large scale. At Birmingham, and at Liverpool, there are also manufactories of a similar description. The uses of the alkali thus prepared on so vast a scale, are various. It is in particular largely employed by the manufacturers of plate and crown glass, and by soap-makers. It is also largely used by chemists, and is an important medicinal substance. Its manufacture is attended with a most annoying accumulation of waste, in the form of sulphuret of calcium, which cannot be applied to any known use,—and colossal heaps of which surround every alkali-works, where this residual matter is placed in mounds, covering otherwise valuable land.

Potash occupies a position of much smaller commercial importance since the introduction of the improved manufacture of soda, than formerly, since the latter has been to a large extent substituted for it. Unfortunately for the manufacturer there exist no stores of chloride of potassium, similar or comparable to those of chloride of sodium—the vast accumulations of which in the salt districts appear to be inexhaustible. He is therefore dependent, as he was formerly for soda, upon the combustion of potash-yielding plants for this alkali. Potash is known in commerce under two forms, as potashes and pearlashes.

The difference in the chemical composition of the potashes and pearlashes of commerce is, that the one is chiefly a caustic form of the alkali, and the other contains more of the carbonate. Both are alike derived from the combustion of wood. America is the chief source of this alkali at present. Her immense primeval forests, upon which the efforts of man make but little impression, present an inexhaustible source of this valuable alkali. The wood is piled up in a pyramidal heap, and the ashes are collected, partly purified, and fused. Pearlash is prepared from the "black salts," or impure caustic and carbonated alkali, by fusion in an open furnace. Potash is largely employed in medicine and the arts. About 5000 tons are annually imported into Great Britain from America alone.

The principal uses of potash in the arts are in glass-making and soap-making. In chemistry and medicine it is of importance, both in its caustic state, and in that of a carbonate. In the latter form it is useful as a source of other salts. Nitrate of potash, or saltpetre, is not obtained from the carbonate, or from the impure potashes of commerce. It is a natural product of the surface-soil of warm countries. India, Egypt, Persia, Spain, and Italy, yield our chief supply. It is obtained from the soil, on the surface of which it makes its appearance like hoar, by lixiviation. The solution is then filtered, evaporated, and crystallized. It is principally imported into Great Britain from Calcutta and Madras. The amount imported from the East Indies and Ceylon in 1841, was 261,552 cwts. Its uses in chemistry and the arts are, for the manufacture of gunpowder, sulphuric and nitric acids. In medicine it is a valuable saline.

Ammonia forms the third alkaline substance of importance in the industrial arts to which we shall briefly refer. One of the most important forms in which this substance is known in commerce is that of sal ammoniac, or muriate of ammonia, which is a compound of ammonia and muriatic (or hydrochloric) acid. This substance was originally prepared in the East, in large quantities, from the combustion of refuse animal matters. But this source of supply has dwindled into insignificance, and immense quantities are now obtained by the destructive distillation of bones, woollen rags, &c., but chiefly by subjecting to proper treatment some of the products obtained from the distillation of coal, as in gas factories. These liquors contain a considerable quantity of carbonate of ammonia. This is converted into sulphate of ammonia by the following ingenious plan.

The crude liquor is made to filter slowly through a layer of pulverized sulphate of lime, two or three inches in thickness, and when the fluid has passed through the first filter it is pumped into a second, similarly constructed; or, if the filters are arranged in terraces on the side of a declivity, it may be run directly from one into another, through proper channels, until the whole of the ammonia has been converted into the sulphate of that alkali, with the formation of an equivalent amount of carbonate of lime.

The last filter should be formed of fresh and nearly pure gypsum, in order to ensure the thorough conversion of the carbonate into the sulphate; and the resulting layer of carbonate of lime is washed with a little water, for the purpose of removing any adhering sulphate of ammonia. The ammoniacal liquor thus obtained usually contains a small quantity of undecomposed carbonate of ammonia, which must be saturated by the addition of a slight excess of sulphuric acid.

The liquid is then concentrated by evaporation, and common salt is added to it, to decompose it. The muriate of ammonia is then separated from the sulphate of soda,—the two results of the decomposition,—by crystallization.

The most ordinary process for converting the ammoniacal liquors of gas works into sal ammoniac, is to saturate them at once with sulphuric acid, and then to decompose the sulphate with common salt, as above described.

The muriatic must then be sublimed, and this was formerly effected by means of stone-ware vessels. But on account of the liability of the stone-ware bottles to become broken, their use is now almost entirely abandoned; and they are at present very generally superseded by large iron pots, lined on the inside with a mixture of fire-clay and powdered charcoal, and covered with leaden domes, in which the sublimed salt is condensed in the form of a large spheroidal cake.

In operating with this apparatus considerable care is, however, necessary to avoid all direct contact of the salt with the iron of the pot in which it is made to evaporate, as the peroxide of that metal is readily volatile in presence of this salt, and when associated with it, imparts a mottled dirty appearance, by which its value is considerably diminished.

Ammonia is most extensively used in the various industrial arts, and the following may be taken as a summary of its uses and applications. Muriate of ammonia is largely used by coppersmiths in tinning copper vessels; for, when washed with a solution of this salt, the thin layer of tin adheres very readily to its surface. This substance is also very extensively employed by engineers, gas-fitters, and water-companies, &c., for making what are called iron joints. This is effected by ramming into the cupped connections of a gas or water-pipe a mixture of iron borings, sulphur, and sal ammoniac, which, from the oxidation of the iron borings, soon becomes cemented together almost as firmly as if cast out of one piece of solid metal. It is also used by boiler-makers for staunching the seams of new boilers by rusting the joints and rivets; and besides being used for a great number of other purposes in the arts, it is extensively employed in medicine as a stimulant. Carbonate of ammonia is much used in colour-making, dyeing, and many other branches of industry; and, when in the caustic state, the volatile alkali is largely employed by the chemists in medicine, and for a variety of other purposes. This form of ammonia is obtained by heating together the carbonate of ammonia and common smelling salts, with caustic lime. Ammoniacal vapours are then set free, and are dissolved in water by pressure.

These three substances, soda, potash, and ammonia form the only alkaline bodies in extensive use in the arts, and of importance in commerce; and their value is, without question, very great, since upon them many of the most extensive branches of industry are dependent. Without a cheap supply of alkali, the glass manufacturer could not carry on his trade except at exorbitant prices, and that of the soap-maker must cease to exist, since soap is a direct combination of certain fatty acids with the alkalies, soda or potash. This substance, soap, is one of so much prominence in an industrial point of view that it might be desirable to mention one or two facts connected with it in this chapter; but, since its principal constituents, oils and fats, belong to the animal and vegetable kingdoms, its consideration will be deferred to the succeeding chapter, which is devoted to these substances.

The three mineral acids, sulphuric, nitric, and hydrochloric, form an appropriate subject for our attention, following the remarks which have now been made upon the three great commercial and industrial alkalies. Of these, the first is undoubtedly the most important, is the most extensively manufactured, and applied to the most varied purposes. Sulphur is imported into Great Britain in enormous quantities annually, principally from Sicily, but other sources also exist, although this is the most abundant, and its products of the best description. It is a volcanic product, and is obtained in great quantity from extensive mines in Sicily. Its principal value is for the manufacture of sulphuric acid, and for this purpose and others 50,000 or 60,000 tons are annually imported. The source of supply in Sicily appears inexhaustible, and if it should fail, or from various circumstances cease to be available to the manufacturer, it fortunately happens that numerous other sources exist, and would speedily be rendered serviceable. Sulphuric acid consists chemically of one part of sulphur by weight, united with three parts of oxygen gas. In addition, it contains water, with which, in fact, it appears to be in chemical union, so that what we call sulphuric acid may, in reality, be a sulphate of water.

The manufacturer has, therefore, to cause the union of sulphur and oxygen in the presence of water, when he wishes to make sulphuric acid. On the combustion of sulphur in air, it unites with oxygen, but not in the proportions requisite to produce sulphuric acid. The process, as practically carried on at the numerous immense works in operation, in this country, may be described in the following terms.

One of the most striking features of such works is the immense structures of wood, which resemble houses without doors or windows, placed side by side in long lines. These are vast chambers lined with lead, in which the combination of sulphur with oxygen and water is effected. In connection with them is a boiler, which discharges steam into them, and a furnace which evolves the vapour from burning sulphur, and other materials. Upon the floor of the furnace thus alluded to, the sulphur is placed, and being kindled, burns, emitting, in so doing, fumes of sulphurous acid. In a small iron vessel, placed on a tripod over the burning sulphur, are contained some nitrate of potash or soda, mixed with sulphuric acid. This mixture evolves fumes of nitric acid, which mix with those of sulphurous acid, and they are carried forward together to the vast leaden chambers by a tube which opens together with that discharging steam from the boiler. At this point the formation of sulphuric acid begins in the chambers. The sulphurous acid vapour robs the nitric acid vapour of some of its oxygen, and is converted into sulphuric acid, which is dissolved by the water at the bottom of the chambers. This is in due time, when sufficiently charged with acid, drawn off.

This represents, with sufficient detail for our present purpose, the process of manufacture, as far as regards the decomposition of the materials, but it is necessary to state that the view thus given of the reactions which take place is very imperfect,—the general principles only having been stated. Sulphuric acid is drawn off from the leaden chambers when it has a specific gravity of 1·6. It is subsequently concentrated in leaden pans until it begins to act upon the metal, and afterwards it is still more so by evaporation in retorts of platinum or glass. A platinum still has been known to cost 1,000 guineas for this purpose.

The sulphuric acid of commerce is a very heavy liquid, of intensely acid properties, and communicating an oily feel to the fingers if incautiously touched. It consists, in its most concentrated form, of one part by weight of sulphuric acid, and of one part by weight of water. Sulphuric acid can, however, be obtained without water, and then appears in solid fibres, like asbestos, which may be moulded like wax by a little manipulation. It is remarkable that in this state it does not exhibit the usual effect of an acid on litmus paper, namely that of reddening it. It is therefore evident, that it is in its combination with water in the form of ordinary sulphuric acid, that its distinctive character as an acid is manifested.

Sulphuric acid is made on a scale of extraordinary magnitude at some of the chemical works of this country, forming, in fact, a distinctive feature of some districts in the North. Probably not less than 70,000 tons are annually made in Great Britain. Its employment in the arts is extremely varied. Its largest use has been already indicated in our observations on the manufacture of carbonate of soda, in which it was seen that it was employed for the decomposition of chloride of sodium, and its conversion into sulphate of soda. It is very largely used, also, in the manufacture of nitric acid, to which it is directly essential. It is extensively used in the dye-works, by the leather-dresser, for blacking, in assaying the precious metals, and in short, in almost every art in which chemical substances are necessary. Large quantities are used by the manufacturing chemist for making sulphate of magnesia, and also for evolving carbonic acid gas from chalk in the manufacture of soda-water.

The nitric acid of commerce, known in an impure state as aquafortis, is not manufactured on a scale at all approaching to that of sulphuric acid works. Its uses are less extensive, and it is consequently a more costly article than the latter. Just as there exist in nature inexhaustible stores of material for the production of soda, in our mines and springs of salt, so the vast quantities of nitrate of potash which are found in the soils of India and Spain, and of nitrate of soda, which exists in that of certain districts of South America, represent exhaustless stores of nitric acid. This acid consists of one part, by weight, of the gaseous element nitrogen, united with five parts, by weight, of oxygen. But, unlike sulphuric acid, which can be obtained without water, nitric acid cannot exist, except in combination with water, in which state it is obtained by the manufacturer.

It is prepared in the following manner; a quantity of nitrate of soda, or nitrate of potash, is mixed with an equivalent quantity of sulphuric acid, in large cylinders of cast-iron, supported in brick-work, over a fire. A pair of these cylinders is generally heated by one fire, and their extremities are of glazed stone ware, or of discs of stone. By the application of heat, decomposition of the mixture takes place, and nitric acid rises in vapour; as this would attack and soon destroy the iron cylinders by its chemical action, the interior of the upper part is defended from the influence of the vapour by a lining of fire clay, or of earthen tiles cemented together. The vapour is conducted away from the cylinders, and is received and condensed in large vessels of stone ware, placed in cold water, from which it is afterwards withdrawn, and, if necessary, concentrated by distillation.

The decomposition which takes place in the cylinders is as follows. The sulphuric acid unites with the potash or soda, of the nitrates used, and forms a bisulphate of potash or soda, at the same time liberating the nitric acid, which was previously in combination with these bodies, and this, rising in vapour, with some of the water of the sulphuric acid, is condensed in the receivers, as above detailed. Nitric acid is a fuming liquid, and, if pure, is colourless; but is decomposed, to a small extent, by the light.. It exhibits most powerful acid properties, and rapidly acts upon metals, and in a most remarkable manner upon organic substances.

Among other uses to which nitric acid is applied, perhaps one of the most singular is its employment in conjunction with the acid previously described, sulphuric, for the preparation of gun-cotton. This extraordinary substance, originally discovered by Professor Schonbein, is obtained by immersing fine cotton-wool in a mixture of nitric and sulphuric acids for a few minutes. It is afterwards removed, and washed in water and dried, when it is found to have acquired the most powerfully explosive properties. Hitherto the application of this substance in the arts has been limited by its extreme liability to ignition at very moderate temperatures. But it has been proved to possess important advantages in blasting, and other operations requiring explosive action. For artillery it is useless, from the fact that the heat of the piece, after once or twice firing, is sufficient to ignite it. It remains to be seen whether its explosive power can be retained, and its temperature of ignition elevated. If so, it will become a valuable substitute for gunpowder. It is soluble in ether, forming a remarkable mucilaginous liquid, used by surgeons occasionally, and called collodion. Nitric acid is of the utmost value to the chemist, and is employed, to a very large extent, in a variety of arts and manufactures. It is particularly used by lacquerers, for giving a bright surface to tarnished brass work. Nitrate of soda, which, as above remarked, is a natural product, is valued as a manure, and nitrate of potash for the uses already named.

The last of the mineral acids to which we need allude is hydrochloric, or muriatic acid. This acid is also popularly known as spirits of salt, a name originating in the process by which it is commercially obtained. This acid consists of one part, by weight, of hydrogen, and one of chlorine. It is obtained in large quantities, at the alkali works, from the decomposition of common salt by sulphuric acid, the gaseous acid being condensed in various ways, and dissolved in water, is often collected, and made an article of commerce. When the manufacturing chemist makes hydrochloric acid, he adopts the following process. A charge of about three or four cwt. of salt is put into a cast-iron cylinder, very similar to those used for the manufacture of nitric acid, and, like these, protected on the interior of its upper half from the corrosive fumes of the gas by a lining of fire-clay, or tiles. The cylinder is then heated, and when the mass of salt is of sufficient temperature, a portion of sulphuric acid is added to it by means of a long leaden funnel. Decomposition then takes place, and the hydrochloric acid, rising in a gaseous form, is conducted into a series of condensing vessels, made of salt-glaze ware, which contain water, in which the gas dissolves, forming the fluid hydrochloric acid of commerce. The enormous vessels of salt-glaze ware used in chemical factories, are very interesting objects, and a group of the largest kinds is shown in the annexed cut.

COLOSSAL POTTERY WARE.

Hydrochloric acid is a fuming, corrosive liquid, but its acid properties are less vehemently manifested than those of nitric acid. It is of much use in the laboratory, and to the chemical manufacturer, for the production of gases, and other substances. It is employed in the arts, particularly for its remarkable property of facilitating the soldering of zinc, which it does in a striking manner, caused, in some degree, probably by its exposing a perfectly clean surface to the soldering metal. It is also valued as presenting, when mixed with nitric acid, a solvent for gold; such a mixture being called, after the alchemists, aqua regia, or royal water. It is employed also in dye works, and in medicine.

There are some vegetable acids, as they are commonly called, which likewise contribute no unimportant additions to the resources of the industrial arts. These are oxalic, tartaric, and acetic acids, and their manufacture may therefore be considered interesting. Oxalic acid is the natural product of a common plant, the wood-sorrel, in which it exists, in combination with potash, as a binoxalate. But it is obtained by the manufacturer by chemical means of a somewhat singular character.

Oxalic acid may be prepared by the action of nitric acid on sugar, silk, saw-dust, hair, glue, and several other animal and vegetable substances; but for commercial purposes sugar and molasses are alone employed, and yield acid of greater purity than that obtained from any of the other above-mentioned commodities. To make this acid, four parts of nitric acid are added, in a large stoneware vessel, to one part of raw sugar, and the mixture subsequently heated in a water-bath until the whole of the nitrous gas, which is at first driven off, has become totally disengaged. When this point has been attained, the pipkin is removed from the water-bath and allowed to cool, by which means the oxalic acid is obtained in a crystallized form.

Oxalic acid is chiefly used for discharging colours in certain styles of calico printing: it is also employed for whitening the leather of boot-tops, cleaning straw, and other similar fabrics. When combined with ammonia, it forms an exceedingly delicate test for the presence of lime in solution in water, supposed to contain that impurity, such as hard spring water.

Tartaric acid is made, on a very large scale, at several chemical works, and particularly in the vicinity of the metropolis. It is not, however, like oxalic acid, a chemical product, properly so called, but is obtained from the deposit which is found in zinc vats, and commercially called argol. This deposit consists of an impure bitartrate of potash, or cream of tartar, and is formed during the process of fermentation. This substance is decomposed in the following manner:—A large vessel, capable of containing 3000 or 4000 gallons of water, is partly filled with chalk and water, kept at a boiling temperature by steam introduced into it. To this mixture the argol is added by degrees. Decomposition then takes place, and tartrate of lime is deposited, and a neutral tartrate of potash remains in solution. Sulphuric acid is then added, which decomposes this tartrate, converting it into sulphate of potash, and then only tartrate of lime is left. This is afterwards decomposed by dilute sulphuric acid, and the tartaric acid being soluble, while the sulphate of lime is insoluble, it is drawn off evaporated, and crystallized. This substance, together with the last, is very extensively used in calico-printing, to produce what is called the discharge style, the acid taking out in spots the colours of the fabric. It is also largely used for the common effervescing powders.

The manufacture of acetic acid transcends that of either oxalic or tartaric in its magnitude and importance; for, under this head, are to be included, not merely the processes of the chemist for obtaining this acid in its purest form, but also the extensive works for preparing vinegar, which is an impure acetic acid. The manufacture of acetic acid is pursued on an extensive scale in many of our large towns, and the general arrangements adopted may be thus described.

A large cast-iron retort, of cylindrical form, is built into a furnace, and is filled with wood: a brisk fire is then kindled beneath it, and the emission of volatile substances commences. These are conducted by a tube into condensing vessels, in which a large part of them is retained. The furnaces are allowed to cool at night, and, on the following morning, the contents of the iron cylinder, consisting simply of charcoal, and some impurities, are withdrawn, and replaced by a fresh charge when the operation is commenced again. The curious products which arise from this method of distilling wood are very numerous, but the most prominent among them is acetic acid, of which about 35 gallons are obtained at one operation. It is mixed however with a large quantity of tar and other impurities. These are afterwards separated by distillation. But, in order to obtain the acetic acid perfectly free from all admixture, a chemical process is adopted, by which it is ultimately got perfectly pure.

The acid obtained by this process is sometimes called pyroligneous acid, which expresses its origin from the destructive distillation of wood by heat. The woods used for this purpose are the harder kinds, such as oak, birch, ash, &c.—the softer kinds not being suitable. The acetic acid of commerce is obtained, almost exclusively, from this source.

Acetic acid is used to a large extent in several manufactures. It is valuable also in photography, in which art it performs the remarkable function of keeping the light parts of the picture clear and unclouded, without interfering with the proper development of the dark portions. In medicine it is also of the greatest value, and forms important compounds of different kinds. One of its most extensive applications in the arts is for the purposes of the calico-printer, who employs it to prepare the acetates of iron and alumina, so largely used in calico-printing.

Before adverting to other subjects, it will be interesting to give a short notice of another acid also largely used in the various arts, and prepared in a very curious manner.

The origin of boracic acid is extremely interesting. Its principal sources are the celebrated lagoons of Tuscany, where it is obtained by a singularly simple and ingenious process. It rises with steam from the heated earth in a region where volcanic tumult is conspicuously manifest, and was formerly avoided by the superstitious peasantry in its vicinity. This steam is condensed by being passed into basins partly filled with water; the boracic acid is held in solution, purified, evaporated, and crystallized. From 10,000 to 12,000 pounds of this acid are thus obtained every day. Boracic acid occurs sometimes in combination with soda, as a bitrate of soda, and is imported in a crystalline form. These crystals are coated with a rancid, fatty substance, and require to be purified by repeated solutions and crystallizations. When pure, the crystals are white, and have an unctuous greasy feel; they are soluble in alcohol, communicating a green tinge to its flame; when fused they form a transparent glass, and have been found to unite with the oxide of lead, producing a very uniform glass, free from all defects, and said to be adapted for the purpose of telescopes and other astronomical instruments. Borax, as this compound is generally called, is much employed in the arts, particularly in metallurgic operations; also in enamelling, and in pharmacy. It is, in its impure state, the tincal of commerce, and is obtained in large quantities from a lake in Thibet, on the edges of which it crystallizes, and is collected by the natives. It is also procured from lakes in China and Persia. The greater part of the borax of commerce is obtained from the saturation of boracic acid with soda.

The substance well known in commerce, and for medicine also under the name of alum, is manufactured on a scale of such importance as to indicate the extent to which it is used in the industrial arts. This substance chemically consists, in its most common form, of a sulphate of alumina and potash. It is sometimes met with as a natural product in volcanic countries. It is also largely obtained from what is called alum-rock, which, when calcined, yields all the constituents of the alum, sulphuric acid, alumina and potash in several districts in the Papal States, and specimens of this mineral and its products were exhibited in the Exhibition of 1851. But the alum of English commerce is obtained in large quantities from manufactories at Whitby, in Yorkshire, and from Hurlett and Campsie near Glasgow, in Scotland. It is manufactured at both these localities in the following manner, with some slight local variations. A horizontal bed of fuel, composed of brushwood or of small coal, is first made, and upon it pieces of aluminous rock are piled. The fuel being kindled, the whole mass slowly ignites. More rock is piled upon it, until, in some instances, a vast heap of inflamed material, 100 feet high and 200 feet square, is raised, and continues to burn for months. The aluminous schist being thus disintegrated, and its chemical constitution changed, is lixiviated, the solution evaporated in large cisterns and purified, and sulphate of potash or ammonia is then added. The alum thus formed is dissolved, and crystallized by pouring the solution into casks made with moveable staves, called "rocheing casks." On removing the staves, an apparently solid barrel of alum is exposed. The mass of crystals thus exposed is often of great beauty, and is striking in consequence of its size. The cut at the head of this chapter represents some of these immense specimens of crystallization exhibited in 1851. This is pierced with an instrument near the bottom, when the uncrystallized solution runs out. The mass, broken into lumps and dried, is the alum of commerce. The shipments of alum from Whitby in 1841 amounted to 3,237 tons.

But a new process has lately been introduced in the manufacture of this important substance, which will probably ultimately supersede any other source of alum for commercial purposes. This process has been thus described by Mr. Robert Hunt in his Hand-book explanatory of the Great Exhibition.

"In 1845, a patent was obtained by Mr. Spence for the manufacture of alum from the shale of the coal and iron-stone measures. This mineral lies in immense heaps around all our coal and ironstone workings, and was perfectly useless: I am not aware of its having ever been attempted to make any use of it before. It is a compound of varying proportions of silica, alumina, oxide of iron, and bituminous matter; it contains no appreciable quantity of sulphur: after calcining it in the open air, without further preparation, the alumina is extracted by digesting the shale in diluted sulphuric acid, and running off the clear solution of sulphate of alumina of sufficient strength to crystallize, after adding ammonia or potash, and no evaporation of the liquor is required; thus avoiding a very extensive part of all the other processes. This manufacture is perfectly successful; 4000 to 5000 thousand tons of alum have been produced annually at the Pendleton Works: three other firms are at work under the patent, and there is little doubt of its ultimately superseding the manufacture of alum by the other modes and materials. This will be apparent, when it is stated, that there is actually produced one ton of alum from one ton of this otherwise useless and super-abundant mineral."

Alum is extensively used by dyers and calico-printers, and it is on this account chiefly, that its manufacture has assumed its present importance. Its uses are for the purpose of permanently fixing the colours in dyed fabrics, or in technical terms, it is a mordant. It is used in medicine, and extensively to adulterate bread.

The sulphates of iron and copper are very important substances, and like the last are prepared, particularly the former of them, under the unfortunate name copperas, in very large quantities, for commercial purposes. Copperas, to use the term under which it is known in the arts, is a protosulphate of iron, and is obtained by simply exposing iron pyrites, which is a bisulphuret of iron, to the action of the weather. This is done in proper beds made of this material, and well moistened with water. Oxygen is absorbed, and protosulphate of iron is formed, which may then be washed out and crystallized. It is also obtained by acting upon burnt pyrites by sulphuric acid, the sulphuric acid itself being obtained by the combustion of this material in the place of sulphur, for which purpose less than one half of the acid got from it is sufficient. This process is, however, patented. Copperas is largely employed for dyeing, calico-printing, the manufacture of ink, &c. Sulphate of copper, popularly called blue vitriol, is often found in the water of copper mines to which it communicates a blue colour, and from this it can be obtained by evaporation and crystallization. Like sulphate of iron, its principal use is in dyeing.

Bleaching powder, or chloride of lime as it is frequently though not correctly called, forms one of the most valued and indispensable chemical substances in some of the arts, and its manufacture is proportionately extensive. Upwards of half a century has now elapsed since bleaching by chemical agency on the large scale was introduced by Mr. Tennant of Glasgow, by the invention of the substance in question, chloride of lime. This substance is now manufactured in enormous quantities in the following manner:—It is necessary to evolve chlorine gas, and then to expose to it the lime in a state of powder. In order to obtain the gas, the materials employed are sulphuric acid, black oxide of manganese, and chloride of sodium or common salt. When heat is applied to a mixture of these substances, their decomposition ensues, and chlorine gas is given off, and is then conducted to the chamber in which the lime is placed. In order to expose a large amount at one time, the lime is spread out in trays which are placed one above the other, within a chamber made of sandstone. This chamber is carefully secured, so as to obviate leakage of the gas, and is provided with a window through which the state of the interior can be observed from time to time, as occasion requires. After a prolonged exposure to the gas, for three or four days, the lime is found to have absorbed a considerable per centage of it, and now exhales a most powerful odour of chlorine. In this state it is fit for use in bleaching, or for deodorising, as in sick rooms, hospitals, &c.

The process of bleaching by assistance of this compound is one of a remarkable and interesting character, and is daily practised to an extent which must have appeared wholly fabulous to any one living at the commencement of the present century. At the immense print and bleach works in Lancashire we have seen accomplished in a few hours, what fifty years ago occupied as many weeks. The process consists essentially of the following steps. The cloth is first washed in water, then steeped in an alkaline solution at boiling temperature, and after this placed in a vat, in which it is saturated with a mixture of chloride of lime and water. Here it becomes somewhat whiter than before, and is, after a little time transferred to reservoirs containing dilute sulphuric acid and water.

Thence it is transferred to a vat containing a solution of potash or soda, then again to a solution of chlorine, after this it is once more plunged into weak sulphuric acid, then washed, and finally dried. It is then quite white.

Phosphorus, though an elementary substance, is manufactured in very large quantities as a chemical product. Unlike sulphur it is not met with pure in a natural state, and is only to be obtained by the decomposition of some of the compounds of phosphoric acid. The inflammability of this remarkable elementary substance constitutes one of its most familiarly known and valuable properties. It is on this account largely used in the manufacture of lucifer matches, a manufacture which, insignificant though it may appear, in reality is as important and extensive as many others which relate to objects of greater apparent importance. For commercial purposes phosphorus is obtained by acting upon bone-earth with sulphuric acid, and separating the phosphoric acid and phosphate of lime, which are then held in solution by filtration. The solution is evaporated to the consistency of a syrup, and is then mixed with charcoal, and thoroughly dried; after which the mass is distilled in a stone-ware retort, from which a tube is conducted which dips under water. In this manner the phosphorus, in a melted state, distils over, and is received under water, where it remains until it is cooled. It is subsequently melted again, and formed into moulds. Phosphorus is very extensively used in the art of electrotyping. By coating over such non-conducting substances as flowers, or even feathers, and then connecting them with the wires in the decomposing cell in such arrangements, they may be covered over with a beautiful deposit of metal. The lucifer match is tipped with a little paste, which consists of phosphorus united with other inflammable substances.

The principal objections to phosphorus, in its ordinary condition, are its great tendency to ignition at very ordinary temperatures, or by accident, and its offensive smell, which resembles the odour of garlic. In order to obviate these inconveniences, a very remarkable substance has lately been introduced under the name of Amorphous Phosphorus, by Professor Schroetter. The following is an outline of the plan adopted by this gentleman for obtaining this singular substance. He employs manufactured phosphorus of the ordinary kind for conversion into the amorphous state. The phosphorus is placed in a porcelain vessel, within a cylinder of iron closed at one end, and of the shape of a thimble or U. By means of a bath of melted metals the phosphorus is then subjected to a temperature of 500° Fahrenheit, under a slight pressure. By continuation of this heat for some time, the whole of the phosphorus, or nearly, is converted into the amorphous state. The furnace is then allowed to cool, the phosphorus is taken out, washed and dried.

In the Great Exhibition was shown a mass of this substance. It was of a brick-red colour, and cellular texture. It emitted no smell, neither was luminous in the dark. There were also exhibited, and were thus described in the catalogue, "Specimens of matches, made with the amorphous phosphorus. These matches are free from offensive smell, and from effluvia injurious to the workers while they are making them. They give out a brilliant and sure light, when rubbed on the sanded part of the box. They will not take damp so readily as matches made in the usual way. They will keep in hot or cold climates, and in dry or comparatively damp places. They are as cheaply and easily made as the common matches, and are less liable to fire in the process of making. They can be made to light sulphured wood, or stearine matches. The patent safety phosphorus employed in their manufacture may be known by its producing no light in the dark under 400° Fahrenheit."

One or two manufacturers are now engaged in the preparation of this substance for commercial uses, and, if it can be economically prepared, the amorphous will, doubtless, soon supersede the phosphorus as ordinarily prepared. It must be slightly more expensive than ordinary phosphorus from the fact that the amorphous phosphorus has, as we have just described, to undergo a further stage of manufacture.

The last class of chemical substances, of industrial importance, to which we shall allude in the present chapter, are those for the application and production of colour. Many of these are very interesting in their commercial history, as well as in that of their manufacture; but it would prove neither profitable nor indeed possible, to enter into detail on these subjects, as will be apparent when it is stated that the full discussion of a single specimen, as, for example, white-lead, would absorb all the space we are able to devote to that of the whole series. It will be observed that a distinction is made above—into substances for the application, and into those for the development or production, of colour. Of these, those which appertain to the first class, may be arranged under the general head of paints and pigments, and those of the second under that of dyes.

White-lead, or ceruse, as it is often called, will be acknowledged to form one of the most valuable and important of the numerous pigments for use. It is estimated that, of this substance, there are annually manufactured, in Great Britain, not less than about 16,000 tons.

It is, as its name implies, a preparation of lead, in chemical terms a carbonate of lead, generally containing hydrated oxide of lead, which is sometimes combined in the proportion of one atom of hydrated oxide to two of carbonate of lead. The most usual method introduced into England by the Dutch, in 1798, of manufacturing white-lead is likewise the oldest. It consists in exposing lead to the joint action of acetic acid vapour, moist air, and carbonic acid gas. In order to expose a large surface to the action of the decomposing agencies, the lead is cast in the form of stars or gratings, and supported a little above the bottom of earthen pots (in shape like garden pots), into each of which a small quantity of weak acetic acid is placed. The pots are then built up in alternate layers, with spent tanner's bark, until a stack is formed; each layer of pots being covered with boards. The fermentation, which soon takes place in the tan, serves the double purpose of furnishing carbonic acid, and raising the temperature cf the stack, which reaches 140° Fah. After a lapse of six or eight weeks the metallic, or blue-lead, as it is called, is converted into porcelain-like masses of white-lead, which are levigated in water, washed and dried.

The diseases to which the persons employed in white-lead factories are subject, are of a very serious character, and indicate, in a striking manner, the poisonous influence of this substance when introduced into the frame. By certain improvements in the method of producing white-lead, but more particularly in the management of the workpeople, the danger incident to this pursuit may be much modified. By some new processes white-lead is obtained in a very rapid manner, by precipitating it from the salts of lead. But this pigment is inferior to that obtained by the older method. The manufacture proves, however, less injurious to the workpeople. It is very probable that if the persons engaged in this pursuit would take a few very simple precautions, which, in fact, form a part of the enforced rules of some large establishments, such as frequent ablutions, change of the clothes, and occasionally drinking a little lemonade, made with dilute sulphuric acid, instances of lead poisoning would be much less frequent than at present. Very recently, a new salt of lead, the oxichloride, has been proposed as a substitute for common white-lead, and is coming into general use.

The objections which apply to ordinary white-lead have often caused ingenious persons to recommend as its substitutes preparations of other substances, as the sulphate of baryta, and more recently the oxide of zinc. The latter is prepared in large quantities for commercial purposes in Belgium, and is much used also in this country, although it is inferior in its opacity to white-lead, a defect which materially hinders the employment, on an extended scale, of this or any of the other proposed substitutes. The principal employment of white-lead and its substitutes, in addition to the purposes of a direct white pigment, is to serve as a body-colour or ground-work, by means of which the less opaque pigments can be applied so as fully to cover the object painted, that is, to prevent its natural colour from appearing through the coating of paint. The other preparations of lead in use as pigments are the chromates, which are of a beautiful yellow and orange colour, and the red oxide, or red-lead, which is largely used as a substitute for vermilion.

We shall speak of other pigments simply by the colours they exhibit, taking the reds first. Of these one of the most beautiful and costly is carmine, which is obtained from the cochineal insect. The manufacture of this precious material is more successfully prosecuted in France than in this country, and the colour is more brilliant and rich. It has been thought that this is in some measure dependent on the greater brilliancy of the atmosphere. Carmine is obtained by a careful precipitation of the colouring matter obtained from an infusion of the bodies of these insects. The pigment called red-lake is derived from the same source. Another beautiful red colour is that of vermilion, which is a preparation of mercury. It is made by heating together in an iron pot a mixture of sulphur and mercury, which combine to form vermilion. It is used as a pigment by artists, and to a large extent in coloured printing, and in colouring sealing-wax. The common reds are obtained from preparations of lead.

The blue pigments are a very important series. Among them is the well-known substance called Prussian-blue. This is a compound of iron with the element cyanogen. It is obtained by precipitating the sulphate of iron by means of the ferrocyanide of potassium, when a beautiful deep blue colour is obtained. It is used in the arts to a very large extent; by paper-makers for making writing-paper blue, and by paper-stainers, painters, &c. The most interesting colours of this series are obtained from cobalt. The substance called smalt or cobalt-blue, is made to a very large extent in Germany, where its manufacture is carried on in a very interesting manner. The essential details of the process may be given however in a few words.

This substance is essentially a silicate of cobalt, and is prepared by fusing together, in a reverberatory furnace, a mixture of oxide of cobalt, white sand, and carbonate of potash. The fused mass is afterwards powdered and washed in hydrochloric acid, for the purpose of extracting the alkali, which, if allowed to remain, would cause the smalt to lose its colour and assume a black tint on exposure to the atmosphere. A great portion of the smalt manufactured in this country is prepared from the cobalt separated from nickel, used at Birmingham in the preparation of German silver; this is chiefly sent to the Staffordshire potteries, where it is employed for painting on porcelain and common earthenware.

The most splendid and costly of all the series is, however, the long celebrated pigment called ultramarine. The natural variety of this most beautiful blue is prepared by reducing the mineral called lapis-lazuli to an extreme state of division, in which form it furnishes the artist with a most valuable and expensive pigment. For a long time chemists in vain attempted to discover an artificial ultramarine. At length, however, a chemist, by combining in certain proportions, its constituents, succeeded, but kept his process secret for a very long time. Others have, however, also succeeded in preparing it, although the process of its discoverer remains still undivulged. Artificial ultramarine is much inferior, both in colour and durability, to the natural product; but it is still a very beautiful colour, and is prepared in large quantities for the use of painters and paper-stainers. This substance is manufactured chiefly in Germany, where it is made by the fusion of a mixture of several earthy matters, together with sulphur and carbonate of soda. The theory of the production of this body is as yet but imperfectly understood; but its beautiful blue colour is supposed to be in some way connected with the reaction of sulphuret of sodium on silicate of alumina, of which both the natural and artificial varieties contain a considerable amount. It is a curious and interesting example of a splendid colour, produced by chemical combination of substances which exhibit no such peculiarities, for few could have believed that a compound of sulphur, soda, and alumina, would have yielded a compound of such a beautiful hue.

Green pigments are generally obtained by admixture of the blues with the yellows, as of Prussian-blue with the yellow chromate of lead. But some good greens are obtained in a simple form. Of these the compound called Scheele's green, which is an arsenite of copper, is a good example. There are others also of an inferior description in common use. The yellows are principally the chromates of lead, which are obtained in every shade required.

The preparation of the finer kinds of pigments is pursued on the scale of a true manufacture by a few large establishments which supply to artists the materials of the palette. And very rare and costly preparations some of those employed are. The oxides of uranium, cadmium, and other rare metallic elements, are occasionally used for enamel painting. Similar substances are also employed by the painter on porcelain, and the producer of stained glass.

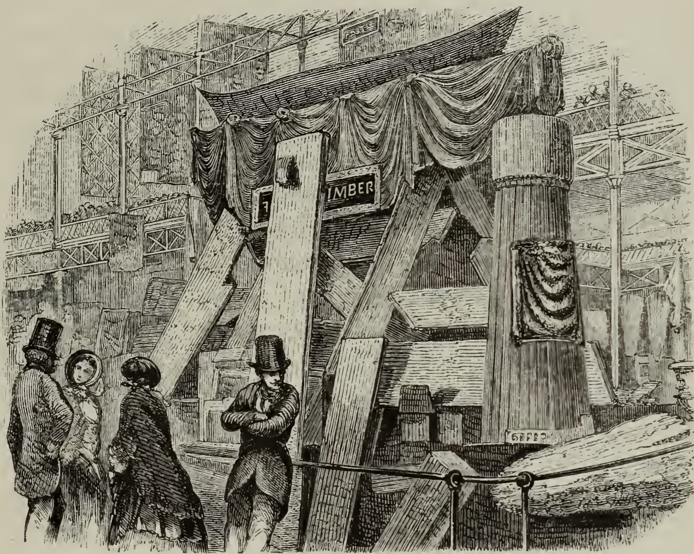
The only substances to which we shall allude in the present chapter, under the second class of colouring matters, namely, those used for the development of colour, as dyes, are the preparations of chromium, and the yellow and red prussiates of potash. The elementary substance chromium, is distinguished as yielded salts and compounds of the most splendid yellow, red, and orange colours. The form in which it is principally met with in commerce is that of bichromate of potash, which is obtained in large crystals of a bright red colour. This substance is produced by the calcination of a mixture of chrome iron ore and nitre, and the subsequent treatment of the liqours obtained by the lixiviation of the roasted mass. Chrome ore, or chrome iron, occurs in large quantities near Baltimore in Maryland, in the Shetland Isles, in the department of Var in France, near Portsey in Banffshire, and also in Bohemia and Silesia. The bichromate is principally employed in the manufacture of the chromates of lead, of the beautiful yellow and red colours of which we have already spoken. The chromates of baryta and strontia are also largely used as yellow pigments.

There are two prussiates of potash in use in the arts; of these the one is yellow, the other red. The yellow prussiate is that most commonly used, and is one of the most important chemical products to the dyer and calico-printer. It is obtained on the large scale by fusing animal matter with carbonate of potash and iron filings; cyanide, and subsequently ferrocyanide of potassium, are produced. The compound, formed on the addition of a salt of iron to the prussiate of potash, is of the most beautiful blue colour, and is called Prussian-blue.

The red prussiate is largely used for the same purposes as the yellow salt, and is obtained from the latter by the transmission of a current of chlorine gas through a solution of it. On evaporating the liquor it deposits beautiful crystals of a ruby colour, of the red prussiate of potash. Both substances are employed in very large quantities in the Lancashire print and dye-works.

In concluding this chapter it may be thought desirable briefly to advert to the condition and extent of the vast chemical works of this country, which form a not less striking feature in our industrial condition, than the wonderful cotton-mills of Lancashire, and machine shops of Manchester and London. These are principally situated in the north and midland counties. Being immediately dependent upon fuel as a source of power and of heat, the manufacturer finds it necessary to erect his works near those places where coal is abundant, and in order to carry on his business on a commercial scale, the facility of transport is a very important consideration. At Newcastle-upon-Tyne, Glasgow, and Liverpool, the largest chemical factories exist. They are concerns in which a large capital is necessary, and they employ many hundreds of operatives in their different departments. The chemical factory at St. Rollox, near Glasgow, has been repeatedly mentioned as an instance of the largest of one of these vast undertakings. The furnaces, works, &c., extend over an enormous area, and their position is rendered conspicuous by a gigantic chimney exceeding the height of St. Paul's cathedral by one hundred feet! These immense chimneys, which are also found at Liverpool and Newcastle, are for the removal of deleterious gases emitted in the processes carried on in the works, which have often cost the manufacturer the expense of a lawsuit, from their noxious properties. The immediate vicinity of such establishments is not to be desired, but their importance, and the benefits to which they give origin, form a subject for due reflection. The more delicate substances are prepared by skilful operators in smaller works, but the coarser chemical products entirely in these great factories. But for these, our textile fabrics must again be sent to Holland to be bleached, and the brilliant colours of our printed cottons must disappear. We trust that this chapter has sufficiently illustrated the important bearings of chemistry upon the industrial arts and manufactures of mankind.

CHAPTER XIII.



MATERIALS OF INDUSTRY.—VEGETABLE AND ANIMAL SUBSTANCES.*

Having in the preceding chapters given a general survey of those mineral and chemical substances which conduce to the prosperity, and are necessary to the right development of the industrial arts, in their widest signification, it remains for us, in the present chapter, to allude to such as are supplied to man by nature, and are by his skill wrought into forms of the most varied character and use. In all civilized and refined conditions of human society, man calls upon every

* The cut represents the Canadian timber trophy of the Great Exhibition.

kingdom of nature to supply the most appropriate materials each can afford for the satisfaction of his wants, or the requirements of his taste. But in savage life, and more particularly in the savage life of tropical countries, it is the universal observation, that only from one of these kingdoms, as for example, the vegetable, are derived those materials which are necessary to the few and simple arts of savage life. The varied uses to which the cocoa-palm is put, supply an apt and interesting illustration of this remark. "Wine, oil, wax, flour, sugar, salt, says Humboldt, are the produce of this tribe; to which Von Martius adds, thread, utensils, weapons, food and habitations. The root of the cocoa-nut is sometimes masticated instead of the areca-nut; of the small fibres, baskets are made in Brazil. The hard case of the stem is converted into drums, and used in the construction of huts; the lower part is so hard as to take a beautiful polish, when it resembles agate; the reticulated substance at the base of the leaves is formed into cradles, and, as some say, into a coarse kind of cloth. The unexpanded terminal bud is a delicate article of food; the leaves furnish thatch for dwellings, and materials for fences, buckets, and baskets; they are used for writing on, and make excellent torches; potash in abundance is yielded by their ashes; the midrib of the leaf serves for oars; the juice of the flowers and stems is replete with sugar, and is fermented into an excellent wine, or distilled into a sort of spirit called arrack, or the sugar itself is separated under the name jagery. The value of the fruit for food, and the delicious beverage which it contains, are well known to all Europeans. The fibrous and uneatable rind is not less useful: it is not only used to polish furniture, and to scour the floors of rooms, but is manufactured into a kind of cordage called coil-rope, which is nearly equal in strength to hemp, and which Roxburgh designates as the very best of all materials for cables, on account of its great elasticity and strength. Finally, an excellent oil is obtained from the kernel by expression."* Thus it is seen, that from a single tree the savage inhabitant of the tropics can obtain almost every material necessary to his condition of life. That such a disposition of things is not desirable in other latitudes, is sufficiently taught by the fact that it does not exist; and as if in a remarkable manner to connect social advancement with the active exercise of industry in many directions, in regions where nature has been less prolific, and man has been imperatively called upon to think and work with the greatest diligence in order to satisfy his wants, we no longer find the same attempt to apply certain materials to every kind of use, but the most fit are selected for each purpose, and the result is a widely organized and prosperous condition, both of society and commerce. The savage, whose wants are almost all supplied to his hand by the cocoa-palm overshadowing his dwelling, has little motive for exertion, and little opportunity for the exercise of any kind of industry beyond that of the simplest description. In the present chapter we propose to show in contrast to this, the various substances from both the animal and vegetable kingdoms, which add their respective contributions to the advancement of the industries of civilized nations.

Timber, it will be readily conceded, is entitled to the first attention under this head. "The use," observes Mr. Porter, "at different epochs, of timber, an article of such general application, exhibits forcibly the comparative progress and industry of a people." Statistical tables show that of timber "8 inches square and upwards, in 1801, the total importation amounted to 161,869 loads, and in 1840 to 807,818 loads. These quantities do not include wood imported in

* The Vegetable Kingdom. Dr. Lindley.

the forms of deals, battens, and staves. In 1843 the importation of all forms of timber amounted to 1,317,645 loads, and in 1846 to the enormous amount of 2,024,939 loads. In the course of about forty years, it is calculated that while the increase of the population was 64½ per cent, the use of imported timber increased 360 per cent. The diminution in the cost of timber may be estimated from the fact, that the cost of the timber, labour, &c., for the construction of a 74-gun ship of 1706 tons, was in 1805, 62,430*l.*, and in 1836, 44,748*l.* In the single item of the oak used, there was a difference of about 5000*l.*, the quantity of this timber necessary, costing in 1805, 18,000*l.*, and in 1836, 13,200*l.*

The prodigious quantities of timber imported from different regions into Liverpool alone will be well shown in the several measurements, in the tonnage and shipping. In 1845 there were brought to Liverpool 11,000,000 of cubic feet of wood, 13,000,000 of staves, 16,000,000 of planks, all which, with logs, fathoms, and other denominations, loaded between 600 and 700 sail of shipping of more than 300,000 tons burthen. In 1849 there was a falling off in these imports; and during the current year it is only lately that an increase has been felt; that increase is mainly in the Colonial and American trades.

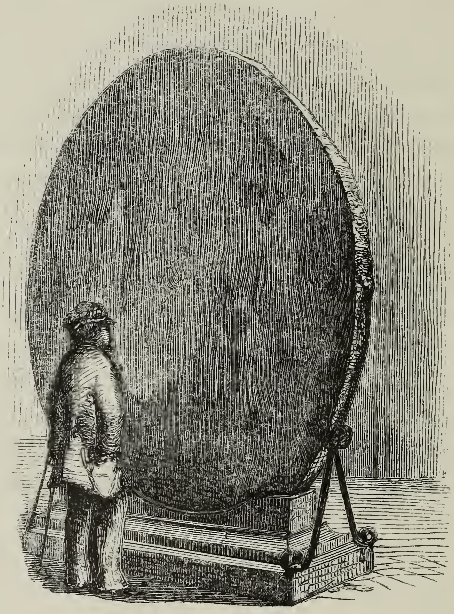
When it is remembered that all this vast quantity of solid material applied to such purposes as the construction of a man-of-war, or to that of a mere ornament for the drawing-room, was once in a liquid or gaseous form, we are presented with a wonderful illustration of the magnitude of the scale in which the chemical processes of nature, and its productive capabilities are arranged. It is a well-known fact that the solid part of wood was once in the form of carbonic acid in great part; and it is clearly proved that this was principally derived from the atmosphere.

When it is considered that such is the demand upon the forests of the world by one kingdom only, and that the quantities used by other countries, or destroyed in various ways, are not taken into account, how vast do our ideas become of the enormous and apparently exhaustless resources of the vegetable world. In comparison with production on such a scale as this, the united industries of the world sink into insignificance.

The principal sources of the supply of timber to this country may be summed up as follows:—"The countries of the Baltic, of the Mediterranean, and the Black Sea; British North America and the United States; Hayti, Cuba, and other West Indian Islands; Central and South America; Africa, India, and the Asiatic Islands; Ceylon, New Zealand, and the South Sea Islands." By analyzing the trade circulars of different timber-dealing firms, we arrive at a very interesting botanical fact, which is this, that a single natural order of plants supplies for the industrial uses of mankind at least four fifths of the annual requirements of this country for timber. This is the tribe of coniferous trees. Some of the quantities obtained from this natural family year by year, are so vast as to pass all powers of realization. Thus in the year 1847, there were imported into England from British America, upwards of 6,000,000 of cubic feet of pine, and nearly 20,000,000 of feet of planks, 2 inches thick. The annual importation of these planks would if placed end to end, reach from one extremity of this island to its opposite. Next to the *Coniferæ*, the largest quantity is yielded by the order to which the birch belongs, the betulaceous trees; and next to this, by the order of which the oak is a member, the corylaceous; then comes the order of the elm, the ulmaceous trees; then the order of the mahogany, the cedrelaceous trees, and that of the teak-tree, the verbenaceous order. Thus it will be observed that, in this country at least, and it may be taken as a pretty accurate type of all European states, at least in this respect, the industrial requirements of the community for timber are supplied, chiefly, by six natural orders of trees. The construction of a single dwelling will exhibit on a small scale, this interesting and valuable fact, and present us with a miniature picture of the demand made by man upon the vegetable world, and upon the different portions of it alluded to. The floors, joints, doors, windows, cupboards, rafters, stairs, and laths, are yielded by coniferous trees,—together with some of the more common parts of the furniture,—and also frequently as the basis for ornamental furniture, which is covered externally by other woods. Our bookcases and similar objects are of oak, and are therefore obtained from the *Corylaceæ;* many of the utensils, and the toys of the children are of birch, and consequently represent the *Betulaceæ;* portions of the kitchen furniture are of elm, the *Ulmaceæ;* the dining-room furniture is of mahogany, the *Cedrelaceæ;* teak is at present little used in our dwellings, but may perchance form a part of the carriage, and thus it represents the *Verbenaceæ.* In addition, the furniture of the drawing-room may be of solid or veneered rosewood; and several of the ornamental objects it contains may stand as the representatives of other ornamental woods. If we multiply these facts by the number of houses existing, or in progress of construction, in which the same general features and similarity of detail is of course observable, we may gain a very tolerable idea of our consumption of timber in this way. But since for the purpose of house construction only a very small proportion of the whole quantities of timber imported are consumed, it is necessary to take also into consideration the other varied purposes for which it is used, if we would possess a true idea of the whole.

Another fact which deserves our attention is, that the immense timber demand of the industrial arts is supplied almost exclusively by Exogenous trees; that is to say, by trees analogous in internal structure to the oak, the elm, &c. A very little consideration will show that this is a necessary result from the circumstances of their growth. Exogens, or outward-growers, as they may be termed, grow by the constant addition of wood on the outside of that previously formed. The increase of their trunks may be compared to that of an icicle: beginning in a minute thread of ice, it grows by the constant freezing of the water flowing over its nucleus. As the water drips outside an icicle, and freezing, adds to its thickness, so the new wood of an exogenous tree is added to its external circumference, and with every year contributes to enlarge its diameter. All the trees of cold climates—from which we obtain the greater proportion of our timber—are exogenous; it is therefore evident from this fact alone, that this class of trees must yield the greater part of the wood used in the arts.

But on examining the structure of an exogenous tree, and contrasting it with that of an endogenous tree, in which the principle of growth is reversed, it will become still more obvious that our supply of timber must of necessity be obtained from the former, and not from the latter class of trees. The section of an endogenous trunk will show that it is of open and loose structure in the middle, while very dense outside. This is principally due to the fact that its increase is effected by the addition of new wood to the interior. From this cause, timber of the size necessary for the requirements of the arts cannot be obtained from the trunk of an Endogen, since the middle of the trunk is so cellular as to be valueless. But the section of most Exogens presents a uniform and solid structure throughout, being a little more dense in the middle, and more loose at the circumference. The trunk of an Exogen will consequently yield a slab of great diameter, and an excellent illustration of this is presented in the cut which represents a circular piece of



VAST BLOCK OF MAHOGANY.

mahogany from Honduras, exhibited at the Great Exhibition of 1851.

We shall confine our observations on the varieties of timber used in the industrial arts, to the notice of one or two of the families of trees yielding the supply. The pine timber of commerce, which it need scarcely be said is yielded by the natural order *Coniferæ*, forms one of the most important of those in ordinary use. Several varieties of it are imported, and some are of native produce. The timber yielded by the Scotch pine, the spruce pine, the Węymouth pine, the silver fir, and the larch, is that chiefly valued. These trees, which are all of the pine species, are those most extensively used, and the wood they yield is adapted to a great variety of purposes. In many of the northern regions extensive forests of pine are found, and form an apparently little exhausted supply of timber for the purposes of mankind. The remarkable manner in which, from some of the mountainous districts in which they flourish, these trees are brought to level ground, is familiar to many readers in the Slide of Alpnach, a vast wooden trough extending for miles, and forming an inclined plane, down which the trunks of the pines are discharged with fearful velocity. From the trees of this species are obtained, in large quantity, the turpentine of commerce, to which we shall here, in a general manner, allude.

These products are obtained in different ways. American turpentine is procured in the following manner. A hollow is cut in the tree a few inches from the ground, and the bark is removed for the space of about 18 inches above it. The turpentine runs into this excavation for a period of about eight months, being transferred from the hollow into casks, which are exported to this and other countries. Canadian turpentine, or, as it is more commonly called, Canada balsam, is received into a bottle from a bladdery protuberance on the stem of the tree. This balsam is very important in the arts; it is used to join the lenses of optical instruments, being in a remarkable degree transparent, so much so that its existence between the glasses cannot be perceived by the eye of an uninitiated person. The ordinary oil of turpentine is obtained from these substances by distilling them with water in a copper vessel. That liquid called camphine, is simply a redistilled oil of turpentine, of much purity and freedom from resinous matters. The remaining substance in the retort is the resin of commerce.

What is known in the arts by the name of wood-tar, is derived from the roots and waste parts of old pine trees. The process has been described in the following terms by Dr. Clarke, as it is now carried on in certain districts in Bothnia. "The situation most favourable to the process is in a forest near to a marsh or bog, because the roots of the fir, from which the tar is principally extracted, are always most productive in such places. A conical cavity is then made in the ground, generally in the side of a bank or sloping hill, and the roots of the fir, together with logs and billets of the same, being neatly trussed in a stack of the same conical shape, are let into this cavity. The whole is then covered with turf to prevent the volatile parts from being dissipated, which, by means of a heavy mallet and wooden stamper, worked separately by two men, is beaten down and rendered as firm as possible about the wood. The stack of billets is then kindled, and a slow combustion of the fir takes place, without flame, as in working charcoal. During this combustion the tar exudes, and a cast-iron pan being at the bottom of the funnel with a part which projects through the side of the bank, barrels are placed beneath this spout to collect the fluid as it comes away. As fast as the barrels are filled, they are bunged and ready for immediate exportation."*

Among other products of a somewhat similar kind and obtained from the same order of trees, the gum resinous substances called Dammar, Sandarach, and Burgundy Pitch, &c., are also derived.

The coniferous trees of Australia have hitherto been little known to commerce, but will doubtless become more so as their value is recognised. The Huon pine of Van Diemen's Land may be mentioned as an instance. The wood of this pine is very largely used in the colony, and is sufficiently ornamental to be applicable to the manufacture of articles of furniture.

* Travels in Scandinavia.

Some fine specimens were exhibited in 1851, both in a raw and manufactured state. Among other articles were organ pipes bored out of solid pine, which were said to yield a softer and more mellow tone than those made of other woods. It was also thought an advantage that there were no joints in these pipes, with glue or other cements, and that they were consequently little liable to be affected by atmospheric changes. Among other Conifers of the same colony, specimens of the pencil pine or cedar, and of the celery-topped pine were likewise exhibited. The first of these, the cedar (*Athrotaxis selaginoides*), or pencil pine, of Tasmania, Marlborough, and Lake Country, is found in the ravines and gorges of the mountain, and the high table-land of the colony, in groups, or singly; sometimes in the forests, and not unfrequently in bare, unsightly groves; of dead, dry, and bleached stems, with a few large limbs attached, at the height of from 3,000 to 4,000 feet above the level of the sea.

The celery-topped pine (*Phyllocladus asplenifolia*) of Tasmania attains a height of 150 feet, and grows in all the cold and moist parts of Van Diemen's Land, in a handsome pyramidal form. The young trees are sometimes used as spars for rigging vessels, but they are too heavy; the timber is very white and close-grained, and useful for household purposes.

It may be interesting to many whose attention was directed to the singular mass of silicified wood, forming a part of the timber trophy of the Great Exhibition, to state that this was a portion of a coniferous tree, and the following is a description of the circumstances in which it was found.*

This magnificent tree was discovered on the estate of Richard Barker, Esq., of Macquarie Plains, Van Diemen's Land, 32 miles from the City of Hobart

* Official Catalogue. Van Diemen's Land.

Town, in the district of New Norfolk; it was 12 feet high, and imbedded in lava, and distinctly surrounded by two flows of scoria, which at some distant day had brought out the juices of the tree to its surface, and became, by a combination of silex, completely vitrified, and surrounded the tree with a glossy surface, the interior of the tree producing opal wood. On a minute examination of the wood by Dr. Hooker, when there in the "Erebus," it was discovered to be a species of tree not growing in the neighbourhood, and appears to be of the pine or coniferous species. It is conjectured it was originally thrown up by an eruption of a volcano to a considerable height, and came down with its heavy end first upon a bed of sand, and had there remained for ages. In describing the tree he says:—"The manner in which the outer layers of wood, when exposed by the removal of the bark, separate into the ultimate fibres of which it is composed, forming an amianthus-like mass on the ventricle of the stump in one place, and covering the ground with a white powder commonly called native pounce, is very curious." It is 10 feet high, and when first discovered, 3 feet 6 inches in diameter, and has been excavated at very considerable expense and labour, and was in a perfectly perpendicular position on the point of a ridge of rocks.

While alluding to the timber of Australia, it may be useful to mention in this place, the probable future value of its immense treasury of blue gum-trees. These trees do not belong to the natural orders already enumerated, but to that of *Myrtaceæ*, or Myrtleblooms. In the Great Exhibition were exhibited two sections of a blue gum-tree taken from one tree at a distance of 134 feet apart. Yet the difference in diameter of the sections was only trifling. The vast quantity of timber obtainable from a single tree of this description, may be estimated from the following account of their growth derived from the same source as the preceding.

"The various species of *Eucalyptus* attain generally a great size both in girth and length in sheltered situations, where the forest is thick, where there is no grass, and where injury has never or very rarely been sustained from bush-fires. Blue gum has been measured upwards of 90 feet round near Tolosa, on the northern aspect of Mount Wellington range, and on the southern side, according to the Rev. T. J. Ewing, one of the species has been measured 102 feet at 3 or 4 feet from the ground. Another *Eucalyptus*, called stringy bark, exists near the Cam River, on the north coast, measuring 64 feet of solid timber at 4 feet from the ground; the tree, having somewhat the form of a four-sided column with its angles bevelled, is 200 feet to the first limb, where it is estimated to be more than 4 feet in diameter, giving the enormous cubic measurement in the trunk alone of more than 1,000 tons of timber."

The principal use of this timber is for ship-building, for which purpose it is said to be quite equal in quality to oak.

The coniferous trees of Canada form a most important part of the export trade of that colony, and among the more abundant of the species exported are those of the white and red pine. The following is an abstract from reliable information on the sources of these trees.

"The valley of the Ottawa is one of the great sources of these two species. The quantity that comes down that river is very large. The greater value of the red pine enables the woodsmen, who are in colonial language called the 'lumberers,' to bring it from greater distances than the other, at the head of Lake Michigan; and the highest point on the Ottawa, at which it has been felled for commercial purposes, is 600 miles above Quebec, the shipping port. From this distance it requires two full months to convey the timber to Quebec; and any accident creating delay would keep it through the winter on the voyage. The highest point from which white pine is brought is 150 miles short of the other; and for the purposes of the voyage, both species are formed into enormous rafts, some of which may have a superficies of 80,000 feet. To pass down rapids it is often necessary to break up the raft into portions called 'cribs' of about 10 logs each; and to obviate the difficulties of cascades, slides are constructed in many parts of the river. The largest white pine-trees of the Ottawa are used for masts, and are of sufficient measure to give planks of 5 feet in breadth, free from sap."

The oak has so long been connected with English history that it must not be passed without notice. The timber of the English oak, *Quercus robur*, has long been celebrated for its strength and resistance to cleavage. Its chief advantage is for the construction of ships of war, a purpose for which it is affirmed that no other timber can equal it in its qualities. The foreign oak is chiefly derived from Canada. It grows chiefly in the western part of the province, and is called the white oak. Oak is also imported from Prussia, and is of very good quality. The bog-oak, obtained in large quantities in Ireland is interesting, and some beautiful specimens were exhibited in 1851, in a manufactured state. It is of a dark colour, finely veined. Except for ornamental uses this timber is of course not available. It is unnecessary to enter into a further consideration of the trees used for ordinary purposes, but some of those employed for furniture remain to be noticed.

The mahogany-tree, *Swietenia mahogani*, forms an article of large annual import into this country from Honduras, St. Domingo, and Cuba, and other places, and to English people it is as familiar as deal or oak.

"The mahogany-tree flourishes in Jamaica, Cuba, St. Domingo, Porto Rico, Central America, and the East Indies. The Jamaica mahogany, though beautiful, is now only to be found at too great a distance from the coast for export. Cuba and St. Domingo have since the abolition of the duty increased their shipments; but the largest trees, and in the extent of country throughout which they are to be found affording a supply which may be said to be inexhaustible, are in the region of Central America."

The trees are marked out by native woodsmen, and afterwards cut down, floated by rivers to their destinations, and thence, after being properly cut, they are exported by ships to various parts of the world.

Some beautiful specimens of the walnut wood exhibited from Canada, the production of a tree called the Black Walnut in that colony, suggest a very valuable source of ornamental timber of the finest and most beautiful kind in that direction. As this wood is quite new to the cabinet-makers of this country, it may be interesting to show the vast dimensions to which it attains in its native forests, and the abundant supply thence resulting if a demand exists. Upon a piece of newspaper pasted on a splendid plank of this wood in the Canadian department of the Great Exhibition, was given the following history of the fall of the majestic tree from which the plank was cut.

"The colossal tree, the largest I think in this country, from which these specimens were obtained, stood in the valley of the Nanticoke, in the township of Walpole. The incidents connected with felling it and getting it into the mill are interesting. It was, I believe, in the winter of 1847, Mr. Fisher commenced operations by constructing a *shanty* for his accommodation while felling the tree and cutting it into logs. It appears almost incredible, but it is certainly the fact, that three men were busily employed a fortnight before the task was completed. The attack upon this giant of the wood was commenced about 10 o'clock A.M. by three first-rate axemen, who continued chopping that day and the next day till nearly night.

"I visited the spot shortly after: the place presented the appearance of a small windfall, so great was the quantity of timber which this huge tree crushed down in its fall. I took the dimensions of it, and if I remember correctly, they were as follow:—circumference at the ground 37 feet; 3 feet from the ground 28 feet: from this the trunk rose, tapering very little, to the height of 61 feet, when it divided into two trunks, the one nearly 6 feet in diameter, the other about 5 feet. These branches stretched up to an enormous height, reaching far above the humble trees of the forest. I could have no idea of the age of this tree, but from the smallness of the annual growths, particularly the latter ones, which were not distinguishable, I concluded it must be very old—perhaps two or three thousand years, and yet it evinced no symptoms of decay; there was not even the slightest hollow in the trunk. There were twenty-three logs in the tree, which made about 10,000 feet of timber: they would have made a much larger quantity; but, on account of the great size of some of them, they had to be hewn down considerably before they could be sawed."

Considerable attention has of late been also directed to the woods of New Zealand, as admirably adapted for the manufacture of furniture. Some very beautiful specimens of furniture, entirely made of these woods, were in the Great Exhibition; and in the New Zealand department were specimens of the woods themselves. The following are some of the names of those exhibited, with their botanical names, as far as ascertained. "Kauri (*Dammara Australis*). Rimu (*Dacrydium cupressinum*). Hakehake. Hakerautangi.

Matai. Kakikatea (*Dacrydium excelsum*). Rewa rewa (*Knightia excelsa*). Pohutukawa. Wairangi pirau (or New Zealand sandal wood). Manuka (tea-tree). Totara (*Podocarpus totara*). Hakerautangi. Kohe. Hinau. Tanekaha (*Phyllocladus trichomaniodes*)."

The capabilities also of the forests of British Guyana were strikingly illustrated at the great industrial display. With regard to the timber trees of this colony, Sir Robert Schomburgk, in his description of British Guyana, published in 1840, p. 116, observes:—"I cannot conclude my observations on the capabilities of British Guyana, without referring once more to the importance of its timber trade, and the source of wealth which might be derived if there were a sufficient number of woodcutters. At present, if we make a few exceptions, it is only carried on by individuals who enter upon it with but little capital and slender means; and yet there are instances where the industrious and sober have reaped riches. The fitness of the timbers for naval architecture is unparalleled, and in some instances is said to surpass the teak. The greenheart, the mora, and souari or sewarri, of all other woods, are most unquestionably the best adapted for ship-building. The woods which are qualified for ornamental purposes vie in elegance, if polished, with any in the world. The want of labourers is the great cause that these treasures lie comparatively hidden, and have scarcely excited attention. The demand in the colony has been so great for native woods, that those who are at present employed in that trade are not able to meet it."

The preservation of timber from decay has occupied much attention, and formed the subject of many ingenious plans, to the principles of one or two of which it is necessary to advert. It is a well-known fact, that wood is liable to a process of decomposition, which will ultimately render it entirely valueless for the purposes of construction. This process advances with greater or less rapidity in different positions; but it appears to affect timber very generally when exposed to the air for a prolonged period; and in some instances the ravages of the rot are so extensive, as to have an importance quite national. The principal ingredient in the wood, which seems to lead to this destructive change of qualities, is a minute portion of albuminous matter, which, by a process analogous to fermentation, leads ultimately to the entire decomposition of the timber. The processes for preserving wood, are, without any exception, intended to effect such a change in the timber, as to arrest and prevent the decomposition in question.

By one of these processes the wood is saturated with oil of tar, or cilorote. This substance exercises a powerfully conservative influence over wood impregnated with it, and is employed for preparing sleepers for the railroads, and piles for submarine works. The wood thus prepared is not only less liable to undergo rot, but also is preserved from the destructive effects of the *teredo navalis,* a creature which, in many instances, has rendered useless some of the most costly works and constructions of engineers. This process has been patented by Mr. Bethell; Sir W. Burnett has also invented a process by which timber is injected with a solution of chloride of zinc; and this process is used in some of the dockyards, where ingenious and powerful apparatus is erected for the purpose of injecting the pores of the wood with the solution. This process is also applicable to canvas, hides, &c. Some remarkable specimens were shown in the Great Exhibition, which had been exposed to the influence of rot, together with unprepared specimens, and the difference in the condition of both was very remarkable. The unprepared specimens being quite decayed, and the prepared being, on the contrary, as strong as when first exposed to the test. Another, and one of the earliest processes for preserving wood, which also appears to be one of the most entirely efficacious, is that of Mr. Kyan, the wood prepared being called after his name, Kyanized. This process consists in saturating timber with a solution of corrosive sublimate, which so thoroughly prevents its decay, that wood after some years of exposure to the air and moisture, still retains its integrity.

In the department of civil engineering in the Great Exhibition, was shown the apparatus represented in the cut. It is a simple and ingenious method adopted in some parts of France for preserving wood, and called Boucherie's process. This process is extremely simple in principle, and requires only such apparatus as a barrel, a tube of gutta-percha, and a wooden box in which the wood is placed. The barrel used is raised to an elevation of some 20 or 30 feet, according to the length of the timber required to be impregnated. It is then filled with a solution of sulphate of copper, or of some other metallic compound, which is conducted from it by the gutta-percha pipe shown in the cut. The timber is then placed vertically,—its lower extremity being connected with the box, communicating with the gutta-percha tube from the cask. It is thus subjected to the pressure of the column of fluid between the cask and the box, and the fluid consequently rises with remarkable rapidity through its entire substance, impregnating every cell in its passage with the metallic solution. Such is the general principle of Boucherie's process. It is as nearly as possible, an imitation of the natural ascent of the sap; and in some of the early experiments, the respiratory force of the tree, while, yet living, was made use of to effect its impregnation with the fluid. This process was exhibited in operation at the French exposition of 1849, and at the Great Exhibition of 1851. On the first occasion it was distinguished by the award of a gold medal. In addition to the value of this process as a means of preserving wood, it has been ingeniously applied to the colouring of wood so as to make it to resemble foreign wood. Wood has also been thus impregnated with various perfumes, and converted into different articles of furniture. The sleepers on some of the railways in France are preserved by this process from decay, and the posts of the electric telegraph wires in a similar manner.

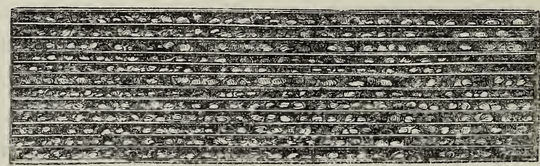
Next to wood, as a material for solid construction, the vegetable and animal materials, classifiable under the general term, textile, will be admitted to take rank in industrial importance. Those materials, which we purpose here to consider under the general term textile, are such as will admit of being twisted, so as to form a cord; the term will be found, consequently, to include the coarse and rough fibres derived from the husk of the cocoa-nut, equally with those delicate filaments which envelope the pupa of the silk-worm, or those which form a part of the wonderful Indian tissues called webs of woven air. Without regard to their being derived partly from the vegetable, and partly from the animal kingdoms, we shall proceed to consider, first, those materials which, in a manufactured state, constitute the fabrics used for clothing and similar purposes: such as cotton for calico, and wool for cloth. In so doing, it will only be possible to make a brief allusion to these substances, either of which might form the subject for a volume, rather than that for a paragraph.

Silk will form the first of these substances. The silk-worm yielding the silk of commerce, is known by the title *Bombyx mori*. Silk itself is virtually an animal secretion, or excretion, which proceeds from a pair of long glandular tubes, terminating in a prominent pore or spinneret on the under lip. The best kind of silk is that, the thread of which is long, strong, very fine, even, and lustrous. There are three principal varieties of the silkworm, as it is cultivated in France. These are called "sina," "syrie," and "novi." "The 'sina' variety," observes Professor Owen,* "of the silkworm is known and esteemed for the pure whiteness of its silk, the thread of which is fine, but weak and not very lustrous. The 'syrie' variety is of large size, produces a cocoon abundant in silk, but the thread is rather coarse, and inclines to a greenish tint. The 'novi' race is small, but the cocoons are firm, and well-made, and the silk has a yellowish tint." The culture of the silkworm has for a long time been most successfully practised in France, where it is carried on very extensively. From a very interesting letter which appeared in the *Morning Chronicle* of April 24, 1851, we shall take the liberty of extracting the following facts on the silk culture of France, a subject of no ordinary interest and importance; making merely such alterations as are necessary to adapt the extract to our present purpose.

"In order to give an idea of the extent to which this culture is carried on, it may be mentioned, that, in the department of the Drôme alone, the number of mulberry trees is computed to exceed 3,000,000—and this independently of a great quantity of dwarf trees of the same class, reckoned as equal to about 300,000 more. The quantity of silkworm eggs annually hatched is stated to amount to about 60,000 ounces; and each ounce, in prosperous years, is computed to produce no less than from 50 to 60lbs. of silk. The average price of a pound of cocoons is about 1¾f. The average price of a pound of spun silk is about 24½f., each 13lbs. of cocoons producing about 1lb. of silk. The total benefit computed to arise to the department by the sale of cocoons is about 5,000,000f."

* Lecture on the Animal Products of the Great Exhibition, p. 109.

The process of breeding and hatching may be described in the following terms. When the early summer time begins to vivify the world, and the mulberry leaves to get juicily ripe, the eggs are hatched, and the barn, or stable, or hayloft to be employed is cleaned out and the apparatus arranged. The latter, as it is commonly used, is easily described. Growing on the banks of the Rhone are large bamboo-like rushes: these are cut, split open, and attached together, so as to form long cane beds, about 2½ feet broad, called *claies*. A portion of one of these is shown in the



COCOONS IN THE CLAIES.

cut. Ranges of these couches are then stretched shelvewise from one end of the barn to the other, upon a rude system of frame-work easily erected—two or more passages, according to the breadth of the chamber, being left longitudinally for the attendants to traverse. The *claies* are arranged one above the other, the lowest about eighteen inches from the floor, the others at like spaces up to the ceiling, if necessary. The place thus presents the aspect of a great barn-chamber, completely filled with long, narrow cane-work shelves, resting upon a rough extempore frame-work of timber, and traversed by narrow passages from end to end. The worms, as soon as they are hatched, are strewed along the *claies*, and the mulberry leaves at the proper moment sprinkled over and among them. Precautions are generally taken to ensure something like an equality of temperature. Holes are cut in the floor and walls to allow the entrance of air, and stoves are used if the nights prove cold. The attendant makes use of a short ladder to ascend to the higher *claies*. In some of the better class of establishments, however, a different and superior arrangement is adopted. The *claies* are ranged so as to hang from the circumference of large wheels placed at each end of the apartment. By turning these wheels the ranges of shelves rise and fall, and are transferred from side to side at the pleasure of the attendant. Brisk currents of air are thus made to play amid the silkworm beds. At the proper moment the creatures are furnished with due facilities for spinning the valuable nest in which they enclose themselves and their eggs. Hedges, or fences so to speak, composed of the cuttings of brushwood, or some such substance, are stuck erect in long lines adown each *claie*, supported between the shelves, and bristling with tough twigs and tiny forked branches. Up these the worms climb, and in them they lay their eggs and spin their cocoons. The whole structure of frame-work and shelf is then pulled to pieces, the brushwood hedges extracted, and the little bunches of silken film picked carefully out from amongst the twigs. The worms inside are killed by the application of steam or boiling water, and if there be a sufficient number of women in the establishment, the spinning of the fibre commences; if not, the cocoons are sold to the agents of the spinners and throwsters, who proceed from farm to farm, gathering in the silken harvest of the year. The labour of attending to the silkworms during the several stages of their short existence is a very trying and harassing one. The operator must be continually on the alert, cleaning the *claies*, providing fresh masses of leaves, regulating the temperature by means of the stoves and air-holes, and removing the dead, sick, or dying worms. The creatures have always to be tended the last thing in the evening and the first in the morning."

The enormous voracity of these creatures will scarcely be credited. The progressive stages through which they pass in their growth are distinguished into ages. The following account gives an idea of the quantity of leaves devoured. The quantities to be stated are those consumed by a single colony of silkworms, consisting perhaps of one hundred thousand individuals.

"On the first day of the fifth age the worms take, in twigs and leaves, about 180lbs. of food. The second day, at least 270lbs. are furnished, the last meal being the greatest. The worms are growing rapidly, and becoming white. The third day the mulberry allowance is 420lbs.—the last meal consisting of about 120lbs. Many of the insects are now 26 or 27 lines long. The next day they consume about 540lbs. of leaves, waxing strong and vigorous, and the length increasing to 32 or 33 lines. The fifth day sees 810lbs. of leaves devoured, besides which small extra allowances are frequently given if the animals seem unsatisfied. The next day the worms attain the height of their degustatory prowess, eating very nearly 1,000lbs. of leaves, spread over five or six meals. Many of them are now more than 2 inches in length. The seventh day 900lbs. of leaves are given—the quantity at each meal decreasing. On this day the creatures attain their greatest size and vigour—sixteen worms weighing an ounce: their weight having in seven days increased fivefold, and their length become at least double. The eighth day they require only 660lbs. of food. They are now going down hill in appetite, weight, and vigour, and are assuming a yellowish tinge, which denotes the approach of perfect maturity. The ninth day 500lbs. of food suffices. On the tenth day the insects commonly show symptoms of desire to weave their cocoons. They climb upon the leaves without eating, move their heads as though seeking something, and begin to crawl towards all perpendicular surfaces. The *claies* upon which the cocoons are spun have then to be set up."

The specimens exhibited by the Sericicultural Society of France at the Great Exhibition, elicited universal admiration, and were rewarded with the council medal by the Jurors. It is mentioned by Professor Owen that the efforts of one exhibitor in improving the breed of this valuable insect had been attended with remarkable success. He appears to have obtained, after numerous experiments, a race of silkworms not subject to disease; producing large and equal sized cocoons, of a pure white colour, the silk of which is equal in all its length, strong and lustrous, and presenting an average length of thread of 1057 metres.

The successful introduction of the culture of the silkworm into certain parts of England was also illustrated at the Great Exhibition by the daughter of the patient experimenter Mrs. Whitby. The labours of this lady were carried on at Newlands, near Southampton, and she appears to have proved the possibility of producing silk of good quality in this country. A beautiful banner of silk was exhibited made entirely of English silk. Similar experiments have been carried on elsewhere. In Guernsey a company has lately been established for the introduction of silk culture into that island, and the peculiar equability and mildness of its climate appear to justify the attempt.

In India, China, and Turkey, the culture of the silkworm has been for many years extensively practised, and most beautiful specimens of raw silk from these countries were exhibited in 1851. It appears to be an ascertained fact that the quality of the silk differs not only with the variety of the worm but also with that of the tree on which it feeds, and, it is said, of the ground in which this tree is planted. The larva of the Tusseh-moth (*Saturnia mylitta*) is also cultivated in India, and yields a strong, coarse kind of silk.

Another kind of silk is the moonga silk, which is obtained from the larva of the *Bombyx saturnia*, and woven into a cloth in Assam. In the same district is also produced a fourth kind of silk, called the eri silk, the larva of which feeds on the tree yielding castor-oil. The true silk, the produce of *Bombyx mori*, is, however, that most universally in repute.

Wool, though less costly than the preceding raw material, exceeds it in industrial importance, in the same way that an article of universal and extensive use exceeds in value a more costly but less used material. This material varies not less than does the preceding in its character and qualities, according to the situation where it is produced. It may serve to indicate the sources of the finest wool to state that, at the Great Exhibition, it was the unanimous decision of the jury that the German wools, under which term were included those from Austria, Silesia, Hungary, Prussia, and Saxony, were pre-eminent in qualities of the highest value. Of one of the specimens from Austria, the following observations were made, which show the nature of those qualities considered desirable in this material. "The fleeces exhibited by the firm of Messrs. Figdor and Sons, presented, in a high degree, the desired qualities of substance and trueness in the staple, due to the equality of size, and to the fineness and elasticity of the component fibres, the spiral curves of which were close and regular, and were immediately resumed, after being obliterated by stretching the fibre, the length of which was also considerable, for wool of this felting quality, the most valuable for the finest descriptions of cloth."

It is a singular fact that the Merino breed of sheep, originally produced in Spain, the wool of which is universally in repute, has been cultivated, in other countries, with far more success than in Spain itself, and this was shown, in a striking manner, by the specimens of Spanish wool exhibited, which were much inferior to the Merino wools from other countries. In Australia, this breed has been introduced with remarkable success, and enormous quantities of wool are now exported, and form one of the most important articles of the trade of that country. The climate combines the qualities essential to a wool-growing district, being dry, with a warm summer and a cold winter. On the Camden estate the late Mr. Macarthur succeeded in rearing those Merino flocks, the germ of which he had, in 1806, introduced into Australia by means of sheep imported in a vessel named by him the "Argo." They have proved one of

SCENE OF THE FIRST WOOL-GROWING EXPERIMENT IN AUSTRALIA.

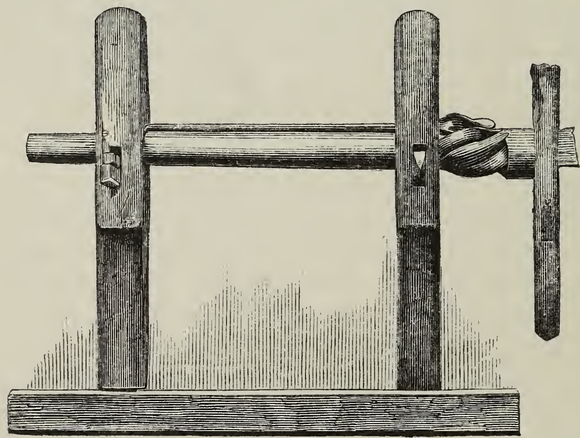
the chief sources of the prosperity of the Australian wool trade, now grown into national importance, and, in the past year, amounting to 36,000,000lbs., valued at 2,000,000*l.* sterling. On the same estate, of which a cut, taken from the original drawing, is given above, an interesting experiment is now being made of introducing the cultivation of the vine. The vineyards are situated on the Nepean River, 40 miles south-west of Sydney.

Among the specimens of wool exhibited by the French wool-growers, our attention, together with that of many more experienced in these matters, and of the jury, was attracted by the remarkable quality of some beautiful samples of wool, called "Mauchamp wool." This wool was singularly glossy, and like silk in appearance, and it was difficult to suppose it to have been produced by the sheep. Its history was elicited by the jury, and embodies the following facts. In the year 1828, one of the ewes of a flock of Merino sheep, in the farm of Mauchamp, produced a male lamb, which, as it grew up, became remarkable for the long, straight, smooth, and silky character of the fibre of its wool. This lamb, on attaining maturity, became the parent of this singular breed, and, after a long series of patient experiments, the owner of the flock has lived to see the complete success of his labours, and the wool produced by his sheep, is considered, by the French manufacturers, as inferior only to the true Cashmerian fleeces, in the fine flexible delicacy of the fabric, and is largely used in imparting to that manufacture those qualities of strength and consistence in which the true Cashmere wool is deficient. The successful introducer of this breed of sheep was rewarded with a Council medal. Among other specimens of wool, were some in the raw, and also in the manufactured state, of cashmere goats, kept by H. R. H. Prince Albert, at Windsor.

To these two textile products from the animal kingdom, silk and wool, we must now add two of equal, and, perhaps, superior importance, cotton and flax. Cotton is imported into this country in immense quantities, from America. The annual imports, indeed, vary, but are generally within the range of a million and a quarter, and a million and a half of bales, each of which weighs about 380 pounds, so that the annual importation of cotton from America alone, exceeds the sum of about 470,000,000 of pounds. These facts serve to give due prominence to this textile material. The plants yielding this substance, are several species of *Gossypium*, and belong to the same natural order as the mallows. There are several varieties of cotton known to commerce. The two most important kinds, of American origin, are the Sea Island, and the Upland. The former of these is the best, and is valued for its long fibres, technically called staple, and its silky character. The plant grows, as the name implies, near the sea, on small sandy islands, scattered along the shores of Carolina and Virginia. The Upland cotton forms the principal part of the cotton of commerce, and is cultivated, to a proportionate extent, in the cotton-growing states. Hitherto, no country has been able to enter into successful competition with the United States, in the production of cotton of the best quality, and indicating the greatest care in its preparation. But considerable quantities are also imported into England, for the cotton manufacturers, from the West Indies, and South America, and also from the East Indies and Egypt. Much appears to depend upon the care used in cultivation, and much also upon the character and properties of the soil. The following observations of a practical writer in the *Morning Chronicle*, of July 12, 1851, give a reliable account of the commercial varieties of this fibre.

"The following well-established varieties are recognised as yielding the chief commercial supplies of cotton:—the Barbadoes cotton, which was long since transported thence to the Isle of Bourbon and the Mauritius, and of which the celebrated long staple cottons of America, the Sea Island, New Orleans, and

Upland cottons are varieties; secondly, the Pernambuco, Brazilian, or Peruvian cotton, distinguished by the peculiar manner in which its black seeds are grouped together in the pod; and lastly, the varieties of the cotton-plant peculiar to China, the East Indies, Arabia, and the shores of the Mediterranean. These various species of the cotton-plant are distinguished from each other by well-defined characters, and the pods which they bear differ from one another in various respects. Perhaps the most important points of distinction are the length and character of the fibre, and the relation which it bears to the seeds; in some cases the seeds are easily separated from the cotton—in others the fibre adheres so strongly to the seed that it can only be separated with the greatest difficulty, and, in that case, the fibre is almost always injured in the process of cleaning it, whether by the gin or otherwise."

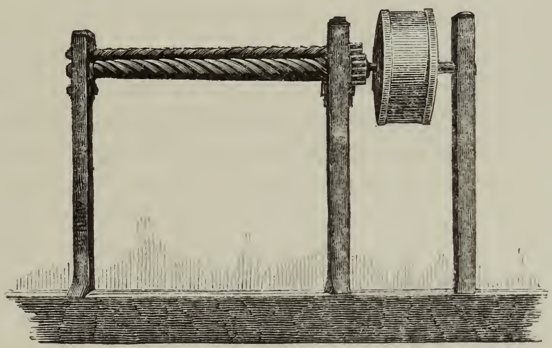


NATIVE CHURKA FOR COTTON.

The above cut represents the rude and simple instrument, adopted in India, for removing the cotton-fibre from the seed. The following is the catalogue description of it:—

"No. 2 is a native churka, though not exactly in common use; it is more expensive than the first, and costs about 3*s.*; but the great drawback is that the wooden roller soon wears out, and is not easily replaced, as great accuracy is required that the spirals in the screws fit perfectly into each other. In effectiveness it is rather better than the common roller. It is used in the province of Agra, in India."

Below is another of these machines with a pulley, to be driven by steam or water. The extreme simplicity of these instruments deserves notice.



CHURKA FOR STEAM POWER.

It has been a subject of much experiment and of most earnest inquiry whether England might not avail herself of her vast possessions in India as a source of this important article for her manufacturers. The best cottons of India are, however, inferior to those of America, in the shortness of their staple, and in the coarseness of the fibre. In addition to these defects, are those which are dependent on the negligence and want of attention of the cultivators and on the dishonesty of the middlemen, the dirty state of the fibre and the adulteration to which it is subjected. The short-sightedness of this commercial dishonesty is apparent, for the cotton is, after all, depreciated in value, and with its adulterations only sells for what it is worth. India is capable of producing cotton little, if at all, inferior to the average American kinds, but only under European management or inspection. In the season of 1850-51, it is stated by Dr. Royle that not fewer than 9,000 bales would pass through one station in their way to England.

The cottons exhibited in 1851, from different countries, were of very different qualities and characters. They were interesting as indicating the variety of sources from which this material may be obtained. Thus there were specimens from West Africa, and also from Port Natal, some of remarkable excellence from Jamaica, Barbadoes and Trinidad; some interesting specimens from Borneo, from Egypt, China and Peru, from Spain and Portugal, and from the French colonists in Algeria. Some of these were samples of excellent quality, others were of average character, and some were inferior in their nature. It would be interesting to learn whether, as a result of the Exhibition, any of these sources should come to yield still larger supplies in future for the great factories of Lancashire.

Flax cultivation in England has, of late, attracted much attention, and may justly be considered as of national importance. The amount of this textile substance used by our manufacturers in 1849, as imported from other countries, amounted to nearly 2,000,000cwt. The whole quantity of flax and hemp imported in a fibrous state into this country being of the annual value of nearly five millions sterling. The plant from which flax is obtained is one of familiar aspect, its botanical name is *Linum usitatissimum*. The tenacious fibres valued by the manufacturer are obtained from its inner bark. The preparation necessary for the fibres is as follows: — the plants are first, after being pulled, spread out to dry; they are then steeped in water, in running water in some districts, in still water in others; this disintegrates their tissues, and they are then spread out on the grass, and dried. After this the fibre is detached by means of appropriate machinery, and after undergoing various processes is fit for spinning. The method of cultivation and preparation adopted in Belgium produces flax of the very finest quality, for which purpose it is imported into England, and is chiefly used in the manufacture of the finest class of fabrics. It is said that the purity of the water in which the flax is steeped, materially influences the quality of the flax. The culture is principally carried on in the Courtrai district, and the clear waters of the river Lys are employed for the steeping process. The total value of flax produced in Belgium is estimable at about two millions and a half sterling. The principal portion of our present supplies is obtained from Russia, and several qualities are distinguished in commerce. Next to Russia our largest imports are from Holland, then from Prussia and Belgium. But the quality of the Belgian flax is superior to any grown at home or received from other countries. It would appear, that from India two good supplies might be derived, for it is stated by Dr. Royle that the stalks of the flax plant are thrown away in many districts, although growing in abundance and capable of yielding fibre of good quality.

The existence of a new process of treating flax, patented by M. Claussen in this country, has very recently attracted much notice in England, and would appear to promise valuable results. In order to prepare long flax for the linen manufacturer, the flax is boiled (either in the straw as it comes from the field, or in the state in which it leaves the growers' hands, with its bulk partially reduced by mechanical means), for two or three hours in a weak solution of caustic soda. The action of the soda dissolves completely the resinous and other substance of the plant, while, by its combination with the oleaginous matters that it contains, it produces a soapy kind of liquid, which removes at the same time all the colouring matter from the plant—leaving it, unlike flax steeped upon the ordinary mode, free from all stain and impurity, and thereby facilitating greatly the after processes of bleaching or dyeing, whether in the yarn or in the finished cloth.

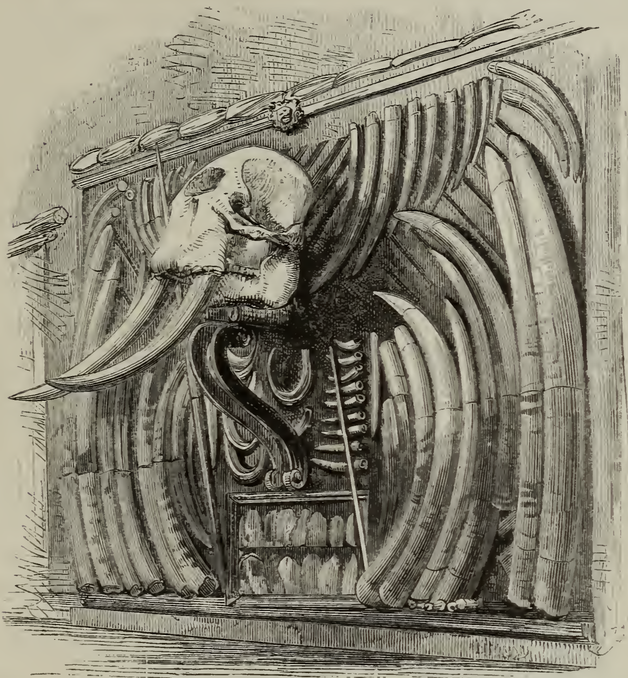
"The fibres of this length are not, however, adapted to cotton-spinning; the material, therefore, requires a further preparation for the use of the cotton spinner. The first step necessary in this process is the reduction of the flax fibre to lengths adapted for spinning on cotton machinery. These required lengths are obtained by a very nicely adjusted piece of mechanism, similar in its principle to the ordinary chaff-cutting machines. It is here that the greatest accuracy is required, as, if any of the fibres exceed the required length, the yarns produced will 'bite' in the rollers and present the appearance of being 'overworked,' and will also be unequal in strength. The flax may be cut for this purpose either in the straw as it comes from the field, with its bulk partially reduced, or after it has undergone the boiling process. But in order to spin flax successfully upon cotton machinery, something more is required than the mere reduction of the length of the fibre. After having undergone the boiling or steeping process, and when the glutinous matter which binds them together is removed, the fibres, however fine, are still harsh, coarse, and elastic when compared with cotton; and the quantity in length of yarn obtained from equal weights of flax and cotton would be so greatly in favour of the latter, as completely to preclude the possibility of the former being substituted for it.

"The most novel and singular part of the process is that which now follows, and by which the nature of the fibre is entirely altered. In order to effect this, it is placed in a vat containing a solution of carbonate of soda, till saturated with the salt, and afterwards put into a bath containing a weak solution of sulphuric or other acid. The hollow cylinders of the fibres will, by the laws of capillary attraction, speedily become charged with the acidulated solution in which they were placed. The acid, coming in contact with the soda which the fibres had taken up in the first and second solutions, will generate carbonic gas, the expansive force of which will split or divide the fibres into a vast number of ribbon-like filaments, which, examined under the microscope, will present all the appearance of raw cotton."

The bleaching is effected in the ordinary way by plunging the so-called flax cotton into a solution of the ordinary bleaching powder. In this way it is very rapidly bleached and fit for manufacture. An interesting series of specimens illustrative of this process were shown at the Great Exhibition, and received an award. The textile fibre thus produced takes dyes of various colours with great readiness. It is also prepared of various lengths of staple, and some specimens resembled wool and were wrought into flannel. Experiments are now being made on a large scale which will soon determine the applicability of this invention to the wants of the manufacturer. The great question of economy of production is one, the first of many which will have to be solved in its introduction.

There are many other fibrous substances which are allied to flax in the character of the fibre, though obtained from other plants. Hemp, which is used in large quantities for sailcloth and cordage, for which purpose it is imported into England from Russia, Italy, and the East Indies is one of the most important of these. But it would really appear that as yet, manufacturers are only to a very small extent acquainted with the resources in fibrous materials of the vegetable kingdom. Among other substitutes for hemp, attention is now being drawn to a fibre obtained in large quantities from the East Indies, and called *Sun*, under which name it is imported into this country. It is said to be yielded by a species of *Crotolaria*. Another and a more important substitute is called *Jute* or *Fat*, derived from the same source. This fibre is very long, fine, and cheap. It is used for making ropes, &c., and in weaving mixed with flax. At the Great Exhibition a variety of other fibres were exhibited with tissues made from them. Among those of interest were some fine tissues made from the fibre of the great aloe-tree, the pine-apple, and plantain. Perhaps the most interesting of this series is the fibre now largely imported into this country under the name China grass. Many specimens of very fine linen made from this material were shown at the Exhibition. This is called nettle, or grass cloth, but it is in fact yielded by a plant allied to the nettle tribe, and called *Boehmeria nivea*. It has become an article of extensive import into this country, and is applicable to very fine manufactures. There can be little question that in a few years most important additions to the whole of the vegetable textile series will be made, and that India will be the principal source of future supply appears also extremely probable.

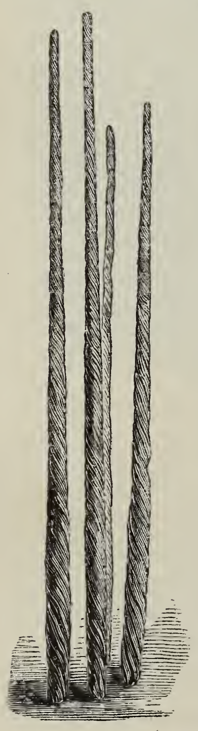
The accompanying engraving presents a view of some of the solid contributions of the animal kingdom to the uses of the manufacturer, and was taken from a collection exhibited by Messrs. Fauntleroy, at the Great Industrial meeting of 1851. It comprised, as will be seen from the illustration, not merely some magnificent specimens of ivory, but several other specimens of animal produce used in different arts, such as the tusks of the hippopotamus and of the walrus. We shall briefly advert to these materials.



TROPHY OF ANIMAL SUBSTANCES USED IN MANUFACTURES.

Ivory has been long known and used in the arts and manufactures, and is the most valuable and extensively employed member of this series. This substance is yielded of the finest quality by wild elephants; and it has been stated that domesticated ones only supply short and inferior tusks. Fine ivory is distinguished, on the authority of Professor Owen, by the intersecting curved lines which are visible on the surface of a cross section of the tusk. There were several very fine specimens of elephants' tusks at the Great Exhibition. The most remarkable of these were a pair weighing

325 pounds, obtained from an animal killed near the newly discovered Lake Ngami, in South Africa. Each of these great tusks measured 8 feet 6 inches in length, and 22 inches in circumference at the base. One of the large tusks exhibited in the cut did not weigh less than 139 pounds. In order to cut ivory for the use of the miniature painter, it is divided by an extremely thin saw acting horizontally, and cutting off the ivory just as one pares an apple; so that from a solid tusk of very ordinary circumference, a sheet of considerable breadth can thus be pared off. One manufacturer exhibited a sheet of ivory thus pared off, which was 60 feet in length, obtained without joining, from a single tusk. The varied purposes to which ivory is applicable are so familiar, as to render it unnecessary to make further allusion to them in this place.



TUSKS OF NARWHAL.

For some purposes, ivory, beautiful though its structure is, is not so well adapted as other forms of animal substance. Particularly for the purposes of the dentist, in whose art it is necessary to employ a substance of great density, of a pure white colour, and little liable to undergo decomposition. True ivory does not answer these requisitions, and is consequently never employed for the manufacture of artificial teeth. The curiously twisted tusks shown in the cut, which are those of the narwhal, and the tusks of the walrus and hippopotamus, are extensively imported and used in this art. The material thus obtained is very hard, and capable of receiving a beautiful polish; and when skilfully wrought into form, it cannot be distinguished from the natural ivory of the teeth.

Vegetable ivory is a substance to which the attention of the manufacturer has lately been directed. This substance, which bears a close resemblance to real ivory, but of course exhibits none of the markings of ivory, is the nut of a species of palm-tree. This tree, which is a species of *Phytelephas*, is called the Anta by the Indians. It grows in low damp places, generally on the banks of rivers, and is found over the southern parts of Darien, and in the vicinity of Portobello. It is always found in separate groves, and not intermixed with other trees. "The fruit," observes a writer,* "forms large heads; and when the leaf-stalks, which at first support it, have rotted away, it hangs down. A plant bears at one time, from six to eight of these heads, each of which contains on an average eighty seeds, and weighs when ripe, about 25 pounds. With the leaves of the anta the huts of the Indians are thatched; and the young liquid albumen is eaten. The 'nuts,' however, are turned to no useful purpose. The

VEGETABLE IVORY.

Spanish Isthmians did not know, before I visited the isthmus, that *vegetable ivory* existed in their country; and although they have been told that with the pro-

* Journal of Botany, Dr. Hooker.

duce of the groves of Darien whole ships might be loaded, no one has yet taken advantage of the discovery." This substance is represented in the preceding cut. It is now largely used by turners as a substitute for ivory, and is applicable to a variety of purposes for toys and similar articles. But the small size of the nut renders it impossible to apply it to more extensive surfaces, or for the construction of large objects.

Another of the solid animal materials used in manufactures, and of considerable importance, is whalebone, or baleen as it is more properly called. "Whalebone or *Baleen*," observes Professor Bell,* "as it has been called, consists of numerous parallel laminæ, descending perpendicularly from the palate of the *Balæna mysticetus*. Its object, in the economy of the animal, is to form an efficient strainer for its food, which is taken in with the water; and the latter, when the mouth is partially closed, is expelled, leaving the small crustacea and other animals, which constitute the nourishment of the whales, entangled, as it were, in the laminæ of whalebone. Although all the species of *Balæna* possess this substance, it is furnished in the largest quantities, and of the finest quality by the *Balæna mysticetus*, which is the object of incessant and eager pursuit, not only for the value of this substance, but for the immense supply of oil which is obtained from the thick layer of blubber or cutaneous fat in which the body is enveloped. The length of the largest pieces of baleen in a whale 60 feet long, is frequently as much as 12 feet; and the laminæ are ranged in two series, each containing about 300 in number."

Whalebone is imported into this country annually to the amount of some hundreds of tons, and is applicable to many useful purposes. The principal qualities for which it is valued, are its flexibility, tenacity, compactness, and lightness. It is used in umbrellas,

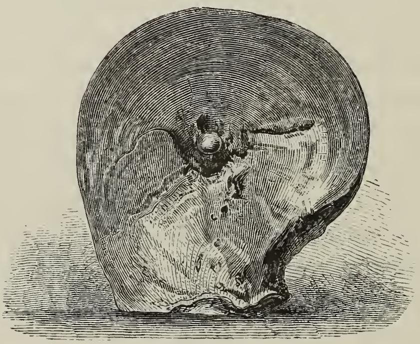
* Official Catalogue of Great Exhibition.

and articles of ladies dress; and when in a prepared state for covering whip-handles, walking-sticks, and telescopes. Shavings of whalebone are used for plaiting, so as to form hats and bonnets, and many other articles are likewise made of it.

Tortoiseshell, horn, and hoofs, may be also classed under this series. The first of these substances is obtained from the Karet tortoises, in the form of plates, which are the covering of the back shell of the tortoise. Extensive importations of tortoiseshell take place both from the East and West Indies into this country, to the amount, it is said, in the aggregate, of about 42,000 pounds yearly. The finest kind is obtained from the East Indies. It is extensively used in the arts, and though successfully imitated by horn, it still continues in demand, and retains its value. Horn is obtained from various sources, and is an article of much greater industrial importance than might have been thought. The horns of the ox and of the buffalo form the chief source of supply. Buffalo-horns are of very fine character, and are principally used in the manufacture of the better sort of articles. Some of them are of very large size, measuring as much as 5 feet in length, and 18 inches in circumference, and weighing nearly 14 pounds. The Indian buffalo from Siam furnishes the best and largest horns. The horns of the ox form, however, the staple article, and are used in immense quantities for the purpose of comb-making, as may be imagined from the fact, that in 1850, one million and a quarter of ox horns were entered for consumption in Great Britain. The chief sources of supply are South America, the Cape of Good Hope, and New South Wales. Hoofs are also largely used for the manufacture of cheap combs, and are subjected to most ingenious machinery in their manufacture.

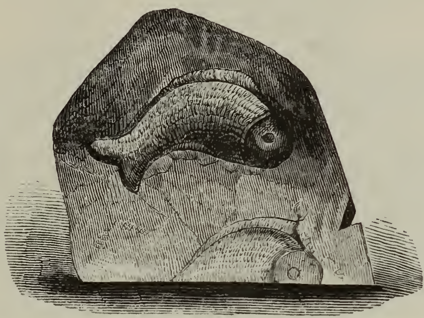
The manufacture of horns and hoofs is now conducted on a most extensive scale in several parts of this country, and an immense establishment exists at Aberdeen. The general principles of the manufacture are as follows: The texture and character of the material is first altered by heat and pressure, the effect of which is to render it of a dark green colour, and perfectly soft. The material is then pressed by powerful mechanism into form, and allowed to dry. When quite dry, the horns are then cut by machinery into combs with teeth, each plate yielding two. The combs are now ready for straining. In order to effect this, they are first immersed in diluted nitric acid, which produces a deep yellow stain, resembling the ground colour of tortoiseshell. In order to produce a variegated appearance, the combs are now treated with a chemical application, containing oxide of lead and alkalies, which leave a stain of a deep orange colour. The combs are then washed and dried, and on being polished so closely resemble tortoiseshell, as to be well calculated to mislead any ordinary observer.

Pearls, and mother-of-pearl, come also into consideration under our present subject, although the first named might almost be classed among jewels. The



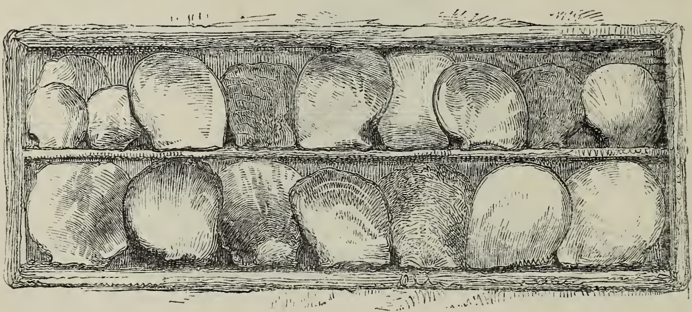
PEARL IN ITS SHELL.

accompanying cut represents a beautiful pearl, in its shell shown at the Great Exhibition by Messrs. Hunt and Roskell. The pearl oyster (*Meleagrina margaritifera*) is principally found in the Indian seas, and the finest pearls are found at Ceylon. The history of the pearl fisheries is probably familiar to every reader. The curious specimens of pearl represented in the next cut were also exhibited by that wealthy firm. The history



of these specimens appears to be this:—small models of fish were placed inside a pearl oyster, which was carefully preserved, and after a time opened. On so doing, it was found that the animal had invested these models with that peculiar excrescence, which in other forms is called pearl. This excrescence consists of concentric laminæ of membrane and carbonate of lime. Pearls have also been found in Ireland and Scotland, and in such cases are yielded by the *Unio margaritifera*, a freshwater bivalve. The largest specimen of pearl known, appears to have been that exhibited by Mr. Hope, in 1851. This pearl is of great beauty; its length is 2 inches, its circumference 4½ inches, and it weighs 3 ounces, or 1,800 grains. Its form is that of a closed hand.

Mother of pearl, or nacre, is very largely used in ornamental manufactures. From India, Manilla, New Zealand, and the Channel Islands, the mother-of-pearl shells are imported into England. The finer kinds are technically called flat-shells, ear-shells, green snail-shells, buffalo-shells, and Bombay-shells, the natural history names being various species of *Meleagrina, Haliotis,* and *Jurbo.* The most esteemed kinds are represented in the cut, which is taken from actual specimens exhibited by Messrs. Fauntleroy, at the Great Exhibition. Mother-of-pearl is very extensively



MOTHER-OF-PEARL SHELLS.

used by the manufacturers of *papier maché,* and for button-making, &c.

Whilst still adverting to the animal raw products used by the manufacturer, it may be worth a moment's consideration to say a few words upon sponge, of which some remarkable specimens will be seen in the annexed illustration. The amount entered for use in Great Britain falls little short of the annual sum of 80,000 pounds. The immense sponges represented in the cut, were exhibited from the Bahamas. They are of a coarse character, and not adapted for personal use. The best descriptions of sponges are obtained from the fisheries of the Mediterranean Sea. Among the isles of Greece, the sponge-fishery is prosecuted with great diligence, and in some parts forms the chief employment of the population. The sea around these isles is so remarkably clear, that experienced divers can distinctly perceive the sponges growing at the bottom.

They are brought up by the divers, after some little

LARGE SPONGES FROM THE BAHAMAS.

difficulty of extraction. The form of these sponges is well shown in the next illustration; and among others is one which was found adhering to a vessel of earthenware. There are several varieties of sponge known in

VARIOUS FORMS OF SPONGES.

commerce, and valued for different purposes. Those from Smyrna are among the most esteemed, and of the greatest value. A singular application of sponge has lately been made, in what are called epithems, a substitute for a poultice. This material is formed of caoutchouc at the back, and a layer of sponge on the upper surface; and when dipped in warm water, forms a very soft and soothing application. The sponge, it is scarcely necessary to add, is now generally acknowledged to form a member of the animal kingdom, though very low down in the scale of organized beings.

Passing from the animal kingdom, two important industrial products, which are somewhat allied to each other, derived from the vegetable world, present themselves to our notice,—these are caoutchouc, and gutta percha. Since a separate notice of these substances is in preparation by the writer of this work, it is less necessary here to advert to them. A few general remarks will, however, probably be acceptable in this place, as both are of considerable value in the arts and manufactures, although their commercial history is very recent, and their entire applicability to the wants of man as not yet developed.

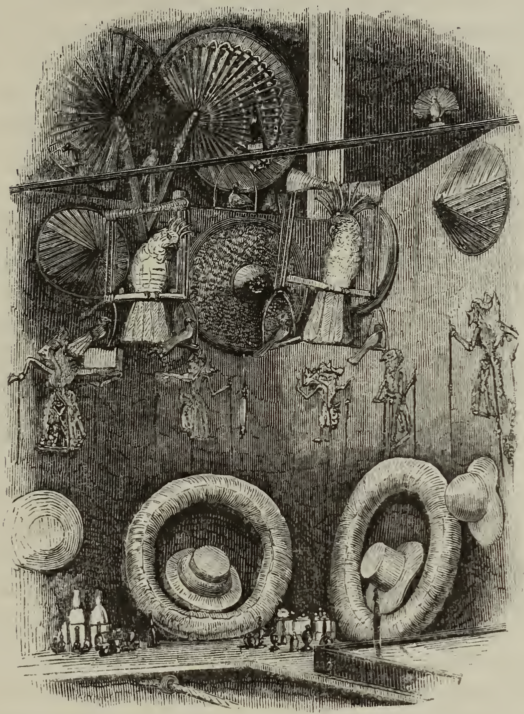
"Caoutchouc," observes Professor E. Forbes, "is the sap of the *Siphonia elastica*, a plant of the order *Euphorbiaceæ* or spurge tribe. The India-rubber tree is a native of Brazil and Guaiana, where it grows to a height of 60 feet and more, running up as a clear stem to 40 or 50 feet, and then branching. The trunk is tapped by a small pickaxe early in the morning, and a cup of soft clay is stuck beneath the wound to collect the milky juice, of which each tree yields daily about a gill. It is then moulded on clay into the bottle or shoe-like shapes in which it is brought to Europe; the layers of juice being dried in smoke. This vegetable constituent is also obtained in large quantities from the East, from the *Ficus elastica* and the *Urceola elastica;* the latter abounds in the islands of the Indian archipelago; it is a creeper so rapid in growth, that in five years it extends to 200 feet, and is from 20 to 30 inches in girth. This tree can, without being injured, yield by tapping from 50 to 60 pounds of caoutchouc in one season; but it is very inferior in quality to that which is obtained from the *Siphonia*."

A combination of caoutchouc with sulphur, originally discovered by Mr. Hancock, and since called vulcanized caoutchouc, acquires an extraordinary increase of elasticity and strength over those of india-rubber in its natural state; and this artificial compound is coming into most extensive use in the arts, and for engineering purposes.

Gutta percha has been known to commerce not more than seven years, and was first introduced to the Society of Arts by Dr. Montgomerie. The original specimens brought over by this gentleman were exhibited in the Indian collection in the Great Exhibition. Gutta percha is the concrete juice of a tree called by botanists *Isonandra gutta*. This tree belongs to the natural order *Sapotaceæ*, and abounds in the Malayan Archipelago. Gutta percha is now exported in enormous quantities from these regions; and unless precautions are taken to prevent the trees being destroyed, there can be little question that in a short time it will scarcely be possible to obtain a supply equal to the demand. The manufacture of both caoutchouc and gutta percha is pursued on the most extensive scale, but for the reason already stated, it is unnecessary to enter into it in this chapter.

Next to gutta percha and caoutchouc, probably, the most useful vegetable substance employed in the arts, is cork. This substance is, as is familiarly known, the thick and soft bark of a kind of oak, (*Quercus suber*). The trees are deprived of their bark every eight years or so, and the extent of the forests of oaks of this kind, may be estimated by the fact, that, about 50,000 cwts. are annually imported into this country. It requires no process of manufacture beyond merely charring it, in order to render it less porous. It is then cut by hand or machinery. For stopping bottles, it is generally cut by hand; but some beautiful machinery has been invented, which effects the same object. A single circumstance, however, renders it altogether impossible for machinery to supersede manual labour in this manufacture. When a piece of cork is cut by hand, the cutter is able to accommodate the direction of the slice he makes, so as to produce a good cork out of what a machine would only turn out a bad one. Out of a certain quantity of cork the hand-cutter would, consequently, be able to turn out a far greater number of corks of first-rate quality, while the machine, being incapable of a similar discretional accommodation, would produce only a few corks of the best kind, many of an inferior sort, and some almost worthless. Cork is cut into plates, however, with great success by machinery; and so beautifully is this adjusted, that 120 plates can be cut out of a piece of the thickness of an inch. These plates are used for various purposes, and to a large extent for manufacturing cork hats. Cork fibre and cuttings are also useful for stuffing sea-mattresses, &c., and present the united advantages of being soft, and also available for the preservation of life from drowning. The corks imported from Spain are in greatest esteem.

There has been much ingenuity displayed at different times in the application of vegetable substances to the production of hats and bonnets, and similar articles, by the simple process of weaving; thus preserving their natural character, and among uncivilized people this sort of talent is often remarkably evinced. The accompanying cut represents a collection of objects made out of beautiful cellular substance by the Hindoos. This substance is the pith-like stem of a plant called *Æschynomone aspera*. The plant is very common in India, in wet and marshy districts, and we are able to give personal testimony to the great beauty of its pith. It is called solah by the natives, and is manufactured into hats, caps, bottle and glass covers, ornaments, toys, &c. The specimens represented formed a part of the Indian collection at the Great Exhibition.



OBJECTS MADE OF PITH.

The most interesting illustration of this remark was, however, on the occasion referred to, to be found in the simple but beautiful articles sent to the Great Exhibition by the Queen of the Society Isles. The catalogue account of these is peculiarly interesting and instructive, and includes, as will be seen from our extract, a description of the production of a beautiful kind of tissue, which we found to be as soft as tissue-paper, and very tenacious also.

"1. Eight fine mats, manufactured by women of the

Society Islands. The tissue is formed of the leaves of the Fara, a variety of the *Pandanus odoratissimus* of Linnæus. The leaves of this shrub are shaped like a long sword, and before using them are submitted to the following preparation:—'After having gathered the leaves, they are buried in the sand close to the sea for about a month, to render them soft; they are then scraped with a shell to render them supple and smooth, this process should be gone through with care, as the fineness of the mat depends on it. The leaves having been thus prepared, are divided into threads which should always be of one fineness for the same mat; for this operation a shell cut like a saw is used. The plaiting is then nothing but an affair of patience.'

"2. Five head-dresses, and eighteen pieces of tissue for ladies' bonnets. These are also made by women. The material used is the plant commonly known in these islands by the name of pia, arrow-root by the English, *Tacca pumalifida* by botanists. The petals of this plant are gathered a short time after it has flowered, and when the seeds begin to form; they are divided into threads and plaited, being rubbed at the same time with a shell on a plank or any other support. This operation causes the green colour entirely to disappear, destroys the inner skin, and leaves only the fibrous parts which are extremely thin. They are then dried in the sun, by which the pia acquires that brilliant whiteness which forms their chief merit. By taking care to preserve them against damp, the bonnets and coronets of pia retain their freshness for several years.

"3. Three pieces of white cloth, manufactured by the women of the Society and neighbouring islands. In this manufacture they employ the bark of the young branches of the *Artocarpus* of Linnæus, commonly called the bread-fruit tree, and known to the inhabitants by the name of maiore or uru. The yellow fringe to this is made from the inner bark of the *Hibiscus* *teleaceus*, and is an article of dress worn by the native chiefs of both sexes. They choose those branches of about 2 or 3 centimetres in diameter, which they strip of their bark close to where the branch joins the tree. This bark is then stripped of its skin and beaten with a mallet. They treat in the same manner the bark of the anté, *Broussonetia papyrifera* of botanists, which is employed also in the composition of this cloth, being used to give it a consistency and whiteness. The two together are then exposed to the dews of the night for three or four weeks, they are then mixed in equal proportions, and formed into little bundles which are beaten with a mallet till they become a pulp. The mallets used are formed partly of stone. At the commencement of the operation the sides of the mallet are rather broad; but as the pulp gets finer the mallets are turned or changed, so as to reduce the size of the beating surface until it is extremely small, and the division of the fibre which it effects, is consequently, also, into very small lengths."

Straw is largely employed, as is well known, for purposes of this kind, and manufactories employing many operatives are constantly engaged in the production of various articles made of this substance. In its manufacture the straw is first cut into lengths, and then sorted into various sizes and qualities. It is then washed and bleached by chemical agency, and is ready for splitting. It is afterwards cut into what are called "splints" for plaiting. There are several kinds of straw plait. When the straw is not split, the kind is called 'Whole Straw Plait." When split, it is called "Split Straw Plait," when the splints are united in a particular manner, it is called "Patent Straw Plait." When the straw is turned inside out, it is called "Rice Patent Plait." In addition to straw for plaiting, other substances are employed. The bonnets called "British Chip," are made out of fine splints of the wood of the

Poplar; others are made from the wood of the Willow. The Tuscan plait has long been valued and celebrated as a material for bonnets, and is still largely used for this purpose. It is the straw of a variety of bearded wheat grown expressly for this purpose on poor sandy soils, and is pulled when green, and then bleached. In England, the straw-plait manufacture is principally carried on in the counties of Bedfordshire, Herts, and Buckinghamshire. From abroad various materials are imported for plaiting, such as the leaf of the palmetto, and what is called "flag-grass," which comes from Cuba, which forms when manufactured, the "Brazilian hats." The amount of manual labour on a single bonnet may be judged of by the fact that in the Great Exhibition there was one made of split straw, consisting of 140 yards of plait, which required 292,320 operations in plaiting, occupying a period of seven weeks, and took ten days in sewing!

The last class of substances obtained from the animal and vegetable kingdoms, and of great importance in the arts, to which we need allude, are the oils and fats, and their compounds. It is not here necessary to allude to the volatile and essential oils, as these are chiefly of use in medicine or perfumery; our remarks will therefore be confined to what are called Unctuous oils and fats. The principal oils of vegetable origin used in commerce are linseed oil, nut oil, poppy oil, olive oil, cocoa-nut oil, palm oil, rape seed oil, almond oil, &c. These, however, form but a very small portion of the sources of oils from the vegetable kingdom. The Indian collection at the Great Exhibition contained a large number of such oils from sources unknown to commercial men.

"Mr. Low," observes Prof. Royle, "mentions that several species of *Dipterocarpus* yield a fatty oil, which having been sent to England, has been extensively used under the name of vegetable tallow and vegetable wax. The seeds of one of the species, called *Meneabang pinang*, yield a very large proportion of oil, which, on being allowed to cool, takes the consistence of sperm. This has been used at Manilla in the manufacture of candles. In Borneo it is called by the natives indifferently "*Miniak meneabang*," or "*Miniak tankawan*." Another oil, expressed from the seed of a tree called *katiow*, is called "*Miniak katiow*." It burns in lamps with a bright and clear flame, and emits an agreeable odour. The *Miniak kapayang* is another oil held in esteem for cooking by the natives of Borneo. It is yielded by the tree, called *Panguim edule* by botanists. Mr. Low mentions, moreover, that the seeds of many of the forest trees, as the *niate* or gutta percha of the Malay Peninsula, produce edible oils of fine qualities. He also refers to wood oils, called "*Miniak kruing*," which are obtained by cutting a large hole in the tree, into which fire being placed, the oil exudes."

The chief animal products of this kind, are sperm oil obtained from *Physeter macrocephalus*, and whale oil from other species, seal oil from *Phoca vitulina*, cod oil, and cod-liver oil, from *Gadus Morrhua*, lard and tallow. The United States, and Russia are the principal exporters of animal oils and fats to this country. From the United States 8,000 kegs of lard are annually exported to Liverpool alone. The chief source of cod-oil is the Newfoundland fisheries, which exported to Liverpool in one year 2,500 tons of this substance. An important article of consumption for lamps is the lard oil, which has been recently sent to this country from the United States, and of which fine specimens were exhibited in 1851. It is obtained from lard by cold and pressure, and is greatly used in America in lamps constructed on what is called the solar principle. It forms an economical and excellent substitute for the best sperm oil.

The manufacture of candles and soap exhibits the most extensive illustrations of the industrial value of the fatty oils, and similar substances. As the demand for fuel as a source of artificial heat is co-extensive with the requirements of mankind, so is that for artificial light. The most important improvements in this respect have taken place during the last few years, and these are chiefly due to the researches of chemical philosophers, and particularly of Gay Lussac and Chevreul into the composition and nature of these substances. It has been shown that there exist two principles in oils and fats called respectively oleine and stearine, the first a fluid, oily substance, and the second a harder and crystalline one. These may be separated to a great extent by means of cold and pressure; the oily part remaining still liquid, and being squeezed out while the harder part becomes more solid, and remains behind. The so-called composite candles are made of stearine, as are all other candles proposed as substitutes for wax or spermaceti. The process of manufacture is briefly as follows. Stearine is prepared from tallow by forming with lime a chemical compound of the fat which is afterwards decomposed by sulphuric acid, diluted. The mass is then compressed by hydraulic force, which expels the oily constituents, and leaves behind a hard semi-crystalline mass. This is fused and run into moulds, and is then fit for the candle-maker. Candles made of stearine were exhibited by many persons from various countries, at the Great Exhibition, showing to how large an extent this valuable discovery has been put into practice. These candles do not require snuffing. For the mechanical details of this manufacture the reader will consult other works.

The soap manufacture like that of candles is carried on in a very large scale in this and other countries, and the substance must be considered one of the primary requisites of every civilized community, and is also greatly used in various arts and manufactures. Soap is a chemical compound of fatty acids with the alkalies, soda or potash. The hard soap is generally made with soda, soft soap with potash. The principal varieties known in commerce are the fancy soaps, and the white, yellow, and mottled soaps. The manufacture is as follows, the fatty matters are boiled with a solution of caustic alkali until combination of the two takes place, this compound is soap, and is forced in a liquid state into fit receivers, from which it is afterwards removed solid, and cut into bars. The amount of soap manufactured in this kingdom amounts annually to not less than 205,000,000 pounds.

With these observations we conclude the present chapter, and with it the present volume of the "Industry of Nations." Our design has been to offer as complete and accurate a picture of the great event of 1851 as was consistent with the permanent interest of our work. In addition we have sought to give an outline of the principal materials employed in industrial occupations. The elaboration of these materials into other forms, and their conversion into machines and manufactures, will be the subjects for another and concluding section of this work.

THE END.

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