design; without peace and pleasantness in occupation, no design; and all the lecturings, and teachings, and prizes, and principles of Art in the world, are of no use, so long as you do not surround your men with happy influences and beautiful things. It is impossible for them to have right ideas about colour, unless they see the lovely colours of nature unspoiled; impossible for them to supply beautiful incident and action in their ornament, unless they see beautiful incident and action in the world about them. Inform their minds, refine their habits, and you form and refine their designs; but keep them illiterate, uncomfortable, and in the midst of unbeautiful things, and whatever they do will still be spurious, vulgar, and valueless." The social question involved in these remarks is one of the highest importance, and deserving of the utmost attention; well would it be for our manufacturing population, in all that concerns their welfare, both of body and mind, if the wise suggestions here made could be practically carried out, however Utopian they appear in an age like this.

One more quotation—it is from the same lecture—and we have done:—"We are about to enter upon a period of our world's history in which domestic life, aided by the arts of peace, will slowly, but at last entirely, supersede public life and the arts of war. For our own England, she will not, I believe, be blasted throughout with furnaces, nor will she be encumbered with palaces. I trust she will keep her green fields, her cottages, and her homes of middle life; but these ought to be, and I trust will be, enriched with a useful, truthful, substantial form of Art. We want now no more feasts of the gods, nor martyrdoms of saints; we have no need of sensuality, no place for superstition, or for costly insolence. Let us have learned and faithful historical painting—touching and thoughtful representations of human nature, in dramatic painting; poetical and familiar renderings of natural objects and of landscape; and rational, deeply-felt realizations of the events which are the subjects of our religious faith. And let these things we want, as far as possible, be scattered abroad and made accessible to all men." Undoubtedly this is the kind of Art England in the nineteenth century requires, but, at the same time, the large majority of Englishmen would not have it expressed, or exhibited, in the manner Mr. Ruskin has all his life advocated.

From these extracts our readers may form some opinion of the kind of materials which constitute these lectures: they embrace a large and varied number of topics, some, as we have intimated, of great value; others, which may be taken for what they are worth. If Mr. Ruskin wishes to be considered an authority in Art, whose lessons are for "the healing of the nation,"—of universal and undeniable benefit, he must get rid of many favourite crotchets, must see with other eyes than those he has hitherto employed, or, at least, like the boy in the fable of the chameleon, must learn to persuade himself that others may see and judge as correctly, perhaps, as himself. His writings and lectures will always command readers and hearers: hitherto they have made few proselytes to his creeds, though they have helped to draw some artists out of a path which was leading them astray; and so far he has his reward.

VISITS TO ART-MANUFACTORIES.

No. 6.—GERHARD'S MANUFACTURE OF ALUMINIUM AND SODIUM.

Everybody talks of aluminium, but, excepting that a few, not very elegant, ornaments are seen in the windows of the jewellers of Paris and London, the public really know but little about it. Some notice, sufficiently popular to convey to all a clear conception of the nature of this metal—*aluminium*—is therefore necessary; and, before we give an account of its manufacture, some space must be devoted to the history of its discovery, and to the physical and chemical condition in which it is found in nature.

We know that the city of Babylon and the great cities of the most ancient empires were built, for the most part, of bricks; some of these were of sun-dried clay, but they were mostly well burnt, and in many cases covered with a vitreous glaze. At a depth beneath the present surface of the sandy soil of Egypt—which, marked as it is by the alternations of sand and mud, from the annual overflows of the Nile, indicate a period of but little less than *twenty thousand years*—vessels of baked clay have been found. *Beneath the Peperino rock*, in the neighbourhood of Rome, also, have they found pottery. When it is remembered that this rock is the consolidated fine ashes which have been ejected from the ancient volcanoes of the Roman States, and that within historic time—beyond the mere tradition of the gulf into which the armed warrior plunged—we have no intimation of any active volcano, we cannot fail to be impressed with the evidence here afforded of a long lapse of ages; at the commencement of which we find indications of the works of man. Yet, notwithstanding that man has, in every part of the world, been constantly moulding clay, and baking and burning it, it was reserved for the present generation to discover that it contained a metal possessed of very remarkable properties, which may be applied to a great variety of useful and ornamental purposes.

Every one is familiar with *clay*, and to a very large number, the different varieties, distinguished as London clay, Poole clay, Stourbridge clay, pipeclay, china-clay, with others, are equally well known. Now these clays are mixtures of true clay—*alumina*—with earthy, ferruginous, organic, and other matters; and by the separation of these we obtain the pure white alumina. This alumina performs a very important part in the great economy of nature; not merely is it the principal constituent of all the clays, but it enters largely into the composition of the rocks themselves. Many of the most highly valued gems are alumina—sapphire is pure alumina crystallized; and the red, yellow, green, and violet varieties, ordinarily known as the oriental ruby, topaz, emerald, and amethyst, are alumina in various states of purity. The following list will show the proportions of alumina contained in some of these, and also in corundum and emery:—

Sapphire of India	97·51	per cent.
Ruby of India	97·32	,,
Corundum of Asia Minor .	92·39	,,
Emery of Gumuch . . .	77·82	,,
Emery of Nicaria . . .	75·12	,,

Alumina, lime, and magnesia are classed with the earths; and immediately connected with the subject before us, are those substances known as alkalies—soda and potash. These well-known salts are found in combination with other bodies in the organic and the inorganic worlds. They are, however, chiefly obtained from the ashes of terrestrial and marine plants. All these bodies, like clay, have been known to man for long periods of time, they have been used extensively in manufactures of all kinds; they were very largely experimented on by the alchemists, yet they were never suspected to have any connection with the metals.

An Englishman of remarkable powers, who advanced himself to the highest honours within reach of the man of science in this country, but who has not yet, owing to the jealousies of his cotemporaries, taken his true position in the history of human progress, was the first to prove that all the earths and alkalies were compounds of metals with oxygen. In precisely the same way as the rust of iron is an oxide of that metal, so are the earths respectively oxides of metals, to which the names have been given of *aluminium*, of *calcium*, and of *magnesium*; so are the alkalies in like manner oxides of *potassium* and *sodium*. The discovery of the metallic base of potash, by Humphrey Davy, in 1807, very naturally opened the door to the discovery of all the others.

Not long since, Mr. Peter Le Neve Foster, secretary of the Society of Arts, at great labour, collected everything that bore in the least on the history of the metal aluminium. He communicated the result of his researches to the Society of Arts, and we avail ourselves of the valuable information contained in his excellent paper. Commencing with Davy's discovery, Mr. Foster thus describes it:—

"Sir Humphrey Davy, in a paper read before the Royal Society, in 1807, made known his discovery of the alkaline metals. He employed what was then a novel agent—voltaic electricity, and by its means decomposed both potash and soda, producing their metallic bases, potassium and sodium. For those important discoveries, on which the science of modern chemistry may be said to have taken its rise, the French Academy conferred upon Davy the prize of 50,000 francs, offered by the Emperor Napoleon for researches in electricity. But though Davy did not succeed in separating by electricity aluminium from its compounds, yet electricity was the means of obtaining it by chemical decomposition, it having been the first source from whence sodium and potassium could be obtained. In this manner, however, they could be produced only in very small quantities, and at an enormous cost. Gay-Lussac and Thénard afterwards made researches in reference to these metals, and succeeded in producing them by direct chemical reaction, but still only in small quantities as laboratory experiments. Subsequently, their researches were carried further by Mitscherlich, Brunner, Donny, and Mareska;* and, following and improving on their labours, M. Deville,† in France, liberally supplied with funds for the purpose by the present Emperor of the French, to carry out researches for the production of aluminium, succeeded in producing sodium in large quantities, and at a price which, though high, was reduced sufficiently low to enable it to be employed in the production of aluminium, at a cost which admits of its commercial use in the Arts for certain purposes, though too high for general use. To enter at length into the description of the methods adopted by M. Deville would occupy too much time. Those who are desirous of entering more minutely into these methods will find them detailed in the papers by M. Deville, in the 'Annales de Chimie,' indicated in the notes. They may be described shortly as consisting of heating at a high temperature a mixture of carbonate of soda, coal-dust or charcoal, with chalk, in an iron vessel, when certain re-actions take place, and the sodium, which is very volatile, comes out in vapour, which, by means of receivers of a suitable form, is condensed, and then runs out in a continuous stream into vessels placed to catch it. It is through the modifications introduced by M. Deville in the forms of the receivers, and the introduction of chalk into the process—which seems to facilitate the reduction in a remarkable manner—that the production of sodium has been rendered more easy and less costly."

Davy felt that alumina must, like the other bodies which he had reduced to a simple form, be a compound body, but he failed to obtain the metallic base. Berzelius followed Davy in experiments on this pure clay, but with no better success. Oersted, however, whose name is for ever connected with the discovery of electro-magnetism, and consequently with the application of electricity as a telegraphic agent, was the first to pursue the correct road. Oersted converted alumina into a chloride, and then acted upon it by the alkaline metals. Wöhler, following Oersted, was yet more successful, and although he does not appear to have obtained the metal aluminium in a coherent form, he did obtain it in a pulverulent one.‡ M. Deville, of the Normal College, in Paris, about the year 1854, began to direct his attention to the means of obtaining aluminium at a comparatively moderate cost, and success crowned his efforts. As above stated, the chief cause of his success was the production of the metal sodium at a cheap rate. As this metal performs a most important part in the process of manufacturing aluminium, it is necessary that we should say a few words on its peculiar properties.

Sodium and *potassium* are metals lighter than water, swimming like pieces of cork upon that fluid. They are brilliantly white and silvery when first cut, but they absorb oxygen with such avidity that they instantly tarnish. So rapidly does potassium separate the oxygen from water, that the liberated hydrogen is ignited by the intense heat produced—hence the metal appears to take fire when thrown on water. Sodium does not exert quite so energetic an action, consequently it does not produce the heat with sufficient rapidity to fire the gas formed by its oxidation on water, but if it is thrown on ice, or on a piece of moistened paper, which are not such good conductors of heat as water is, it inflames like potassium. To preserve these metals, it is necessary that they should be kept in some fluid entirely free of oxygen; Naptha, a pure hydro-carbon, is usually employed for this purpose. When the writer of this paper first commenced his chemical studies,—and nearly at the same time he began to lecture on the subject in a remote provincial mechanics' institution,—he gave for the sodium employed in his experiments

* "Recherches sur l'Extraction du Potassium," par MM. Mareska et F. Donny. "Annales de Chimie," ser. 3, tom. xxxv. p. 147.

† "Recherches sur les Métaux, &c. Annales de Chimie," ser. 3, tom. xliii. p. 19; et "Memoire sur la Fabrication du Sodium et de l'Aluminium," par M. H. Sainte-Claire Deville. "Annales de Chimie," ser. 3, tom. xlvi. p. 415.

‡ "Annales de Chimie," ser. 1, tom. xxxvii.

sixpence a grain, and now, Mr. Gerhard informs him, it can be obtained at one shilling an ounce; and he is sanguine enough to hope that he may be enabled to produce it eventually so as to sell it at one shilling and sixpence the pound—such is the remarkable reduction which has taken place in the cost of an article for which a demand has been created. It is by the powerful affinity of sodium that the manufacturer now removes from alumina the oxygen or chlorine with which it may be combined. Deville discovered that it was more easy to produce aluminium from the chloride than any other preparation. To produce the chloride of aluminium form a mixture of alumina (prepared by calcining ammoniacal alum) and charcoal made into a paste with oil, this is to be heated to a red heat in upright tubular retorts of fireclay, similar to those used in the manufacture of gas, and whilst in this state a current of chlorine gas is to be forced into the retort. Strong chemical action now takes place, and the chloride of aluminium comes over in the form of vapours, and is received in appropriate vessels, where it is condensed.

From this chloride of aluminium the metal was thus reduced by Deville's process:—A tube of Bohemian glass, thirty-six inches long, and about one inch in diameter, was placed in an empty combustion furnace. Chloride of aluminium was introduced at one extremity of the tube, and at the same time a current of dry hydrogen gas was made to enter the tube, and sustained until the operation was finished. The chloride is now gently warmed by pieces of hot charcoal, in order to drive off any hydrochloric acid it might contain; porcelain boats filled with sodium are inserted into the opposite extremity of the tube, and the heat augmented by fresh pieces of glowing charcoal, until the vapour of sodium decomposes that of the chloride of aluminium. A violent reaction takes place, with intense ignition, during which metallic aluminium is deposited. Since this the following process has been adopted:—

"Another method of obtaining aluminium from the chloride has been adopted with success. It is as follows:—

"4·200 grammes of the double chloride of aluminium and sodium (*i.e.* 2·800 grammes chloride of aluminium, and 1·400 grammes common salt),

"2·100 grammes of common salt (the gramme is equal to rather more than fifteen English grains),

"2·100 grammes of cryolite,

thoroughly dry, and carefully mixed together, are to be laid in alternate layers, with ·840 grammes of sodium (cut into small pieces), in a crucible lined with alumina—a layer of sodium should cover the bottom of the crucible. When the crucible is filled, a little powdered salt is to be sprinkled on the contents, and the crucible, fitted with a lid, is to be put into a furnace, heated to redness, and kept at that temperature until a reaction, the occurrence and continuance of which is indicated by a peculiar and characteristic sound, shall have terminated. The contents of the crucible, having been stirred with a porcelain rod, while in their liquefied state (this part of the operation is essential), are poured out on a surface of baked clay, or any other suitable material—the flux, &c., on one side, and the metal on the other." The cryolite here used is simply employed as a flux.

"M. Paul Morin, who, with M. Debray, assisted M. Deville in his original researches, now uses at his factory at Nanterre certain modifications which he has introduced into Deville's process of the double chloride of aluminium and sodium, and gets rid of the necessity for the continued stream of hydrogen gas, as well as the use of the porcelain tube as above described. We believe it is due to M. Morin to state that it was he who first modified Deville's process, so as to admit of the use of the crucible instead of the tube, thus enabling the manufacture to be carried out on a much larger scale."

The next advance was due to Dr. Percy, of the Museum of Practical Geology, who suggested the employment of a peculiar mineral, which is found plentifully in Greenland, called Cryolite. This was in 1855.

Mr. Dick, who was an assistant to Dr. Percy, was the earliest experimentalist with this substance. Cryolite is a double fluoride of aluminium and sodium.

Mr. Gerhard, an Englishman, has for some time been engaged in experiments on the production of aluminium from the cryolite, and his endeavours have been directed mainly to obtain this metal at a cheaper rate than hitherto.

Mr. Gerhard has erected furnaces at Battersea for the production of both aluminium and sodium. His process may be described as follows:—

"Two hundred and seventy parts by weight of powdered cryolite are mixed with one hundred and fifty parts of common salt, and into this mixture are placed seventy-two parts of sodium, cut into small pieces. The whole is then thrown into a heated earthenware crucible, previously lined with a melted mixture of cryolite and salt, which mixture is also immediately poured over the contents of the crucible, covering them to some little depth, over which the lid is then placed. The crucible then put in a furnace, and kept at a high red heat for about two hours. When the pot is uncovered the melted mixture is well stirred, and then poured out. The buttons of aluminium are found mingled with the slag, and may be easily melted together by heating them in a crucible with common salt. Theoretically, the amount of aluminium produced should be one-third of the weight of the sodium employed, but practically such a result is never obtained, and our manufacturers would be well satisfied with obtaining between one-third and one-fourth. This Mr. Gerhard has accomplished, though he is not always so successful. There is still some uncertainty in the process. From what we have seen, we are led to believe that the cryolite process is the one that will ultimately be preferred to that of the chloride of aluminium. As yet, however, the process presents certain difficulties which Mr. Gerhard appears to have to a great extent overcome."

Before Deville commenced his labours, this metal—aluminium—sold at enormous prices. In 1856 it was worth £3 per ounce. Aluminium is now imported from France, and manufactured in this country, selling at 5*s.* the ounce. The most striking property of this metal is its extreme lightness. Its specific gravity is 2·6, about the same as glass; whilst that of gold is 19·5, that of silver 10·5, and that of copper 8·96. An ounce of pure silver is now worth 5*s.* 6*d.* the ounce; an ounce of pure aluminium, which is of three times the bulk of silver, is sold at 5*s.* the ounce, therefore, bulk for bulk, aluminium is but one-third the price of silver. Mr. Peter le Neve Foster, whose inquiries have been very extensive as to the applications of this metal, writes:—

"Already its lightness and colour has brought it into use for jewellery and ornaments of various kinds, bracelets, combs, pins, seals, penholders, tops of inkstands, port-monnaies, shirt-studs, harness, statuettes, candelabra, candlesticks, &c. Its ductility and fusibility render it readily stamped and cast. It works easily under the graver, and being unaffected by the atmosphere, it has an advantage over silver. Its lightness renders it peculiarly fitted for spectacle-frames, eye-glasses, telescopes, and opera-glasses, to which uses it has already been largely applied. It does not stain the skin as silver does. The alloys, too, or aluminium bronzes, as they may be termed, are peculiarly fitted, from the readiness with which they are worked, and their not changing under the action of the atmosphere, for the wheelworks of clocks and chronometers, as well as for the cases, too, for which the metal itself, also from its lightness, is peculiarly fitted.

"Spoons, forks, drinking vessels, and covers for glass vessels, may be made of it, which, even at the present price of the metal, will be much cheaper than silver, while they even possess in a higher degree those qualities for which silver has hitherto been prized. Figuier suggests its use for theodolites, sextants, and surveying instruments which have to be carried by hand, and where, therefore, lightness is important. The adjusting screws of such instruments, which, when made of silver or brass, tarnish from the contact of the hand, might with advantage be made of aluminium. Professor Bleekrode informs me that the working of this metal has, at his suggestion, been taken up by Mr. Meyer, a jeweller, at the Hague, who, amongst other things, has had a small bell cast, the handle of which, as a casting, is equal to anything hitherto done in silver. Mr. Meyer's experience shows that the metal works well under the hammer, is well suited for chasing and engraving, as well as for casting. He alludes to the want of a proper solder for uniting several pieces, and has been obliged to adopt riveting, as in Paris. It has already been used by the dentist as a substitute for gold, in stopping as well as for fixing artificial teeth, both on account of its cheapness and lightness, but the accounts differ as to its fitness.

Mr. Harrington, a dentist in the Isle of Wight, in a paper which he read before the College of Dentists in October last, states that he has used aluminium successfully for dental purposes, and entertains a high opinion of it as a basis for artificial teeth. His experience shows that after wearing it for four months it underwent no apparent change, and was perfectly free from all taste or unpleasantness of any kind. He cautions those who may employ it to be careful in using other metals with it, as even when "wrought" aluminium is used as wire for rivets, or any other purposes, a galvanic action is set up, and the wrought metal is rapidly decomposed, leaving the cast metal unaffected. The metal is highly sonorous, and for musical instruments it has been suggested as especially suited.

Mr. Gerhard has completely overcome the difficulty of soldering aluminium; we have seen as perfect a junction made between two pieces of this metal as it is possible to make between two pieces of copper. This is a great step in aid of the useful applications of this metal.

Many objections have been urged against the colour of the metal, most of that which has been in the market being somewhat like pewter in appearance. By Mr. Gerhard's process the colour is greatly improved, and he possesses the means of rendering it beautifully white. One application which we have seen of this metal—to a watch-dial—had a fine watered surface, which—especially since it is not liable to tarnish under ordinary conditions—is as useful as it is elegant. By far the most important use of aluminium will, we believe, be found in the alloys it forms with other metals. Many of these are very beautiful in colour, some resembling gold; and in all cases it is found to impart a great degree of hardness—even when used in very small quantities—to the metal with which it is combined. Silver, when combined with 1 per cent. of aluminium, is no longer liable to tarnish. Again, if 3 per cent. of silver be united with 97 per cent. of aluminium, it acquires the brilliancy and colour of pure silver, and it will not blacken by exposure to sulphuretted hydrogen. Tissier and Debray inform us that copper, alloyed with one-fourteenth of its weight of aluminium, has the colour and brilliancy of gold, and is still very malleable; when the aluminium amounts to 20 per cent. the alloy is quite white. An alloy of 100 parts of silver with 5 of aluminium is as hard as the alloy employed for our silver coinage; and an alloy of 90 parts of copper and 10 of aluminium is harder than common bronze, and is capable of being worked at high temperatures easier than the best varieties of iron. Dr. Percy, in his laboratory at the Government School of Mines, has made a great number of these alloys, many of them posessing new and very important properties. Messrs. Calvert and Johnson describe an alloy of 25 parts of aluminium and 75 parts of iron, which has the valuable property of not rusting in moist air, or in water. What may we not expect from a metal possessing so many new and useful properties? As a scientific discovery, the fact that clay contains this remarkable metal is amongst the most striking with which chemistry has brought man acquainted. It is amongst the most abundant, if not really the most abundant, of the metals. For tin, and copper, and iron, for gold and for silver, man has to penetrate to the depths of the earth, and the mineral wealth is only obtained at a great sacrifice of human life; but aluminium, in its native combinations, is found in every district, spread over the surface, or near the surface, and the labour of obtaining it is transferred from the miner to the metallurgist. We do not doubt but in a few years we shall find this metal, and some others now as rare as it, rendered available for numerous ornamental and useful purposes.

Robert Hunt.