(*c*) They disproved the "Newtonian law," that the normal pressure varied as the square of the angle of incidence on inclined planes.

(*d*) They showed that the empirical formula of Duchemin, proposed in 1836 and ignored for fifty years, was approximately correct.

(*e*) That the position of the centre of pressure varied with the angle of inclination, and that on planes its movements approximately followed the law formulated by Joessel.

(*f*) That oblong planes, presented with their longest dimension to the line of motion, were more effective for support than when presented with their narrower side.

(*g*) That planes might be superposed without loss of supporting power if spaced apart certain distances which varied with the speed; and

(*h*) That thin planes consumed less power for support at high speeds than at low speeds.

The paradoxical result obtained by Langley, that it takes less power to support a plane at high speed than at low, opens up enormous possibilities for the aërodrome of the future. It results, as Chanute has pointed out, from the fact that the higher the speed the less need be the angle of inclination to sustain a given weight, and the less, therefore, the horizontal component of the air pressure.

It is true only, however, of the plane itself, and not of the struts and framework that go to make up the rest of a flying machine. In order, therefore, to take full advantage of Langley's law, those portions of the machine that offer head resistance alone, without contributing anything to the support of the machine in the air, should be reduced to a minimum.

Contributions to the Art of Aërodromics.

After laying the foundations of a science of aërodromics Langley proceeded to reduce his theories to practice. Between 1891 and 1895 he built four aërodrome models, one driven by carbonic acid gas and three by steam engines. On May 6, 1896, his *Aërodrome No.* 5 was tried upon the Potomac River, near Quantico. I was myself a witness of this celebrated experiment, and secured photographs of the machine in the air, which have been widely published. This aërodrome carried a steam engine, and has a spread of wing of from 12 to 14 feet. It was shot into the air from the top of a house-boat anchored in a quiet bay near Quantico. It made a beautiful flight of about 3000 feet, considerably more than half a mile. It was indeed a most inspiring spectacle to see a steam engine in the air flying with wings like a bird. The equilibrium seemed to be perfect, although no man was on board to control and guide the machine.

I witnessed two flights of this aërodrome on the same day, and came to the conclusion that the possibility of aërial flight by heavier-than-air machines had been fully demonstrated. The world took the same view, and the progress of practical aërodromics was immensely stimulated by the experiments.

Langley afterwards constructed a number of other aërodrome models, which were flown with equal success, and he then felt that he had brought his researches to a conclusion, and desired to leave to others the task of bringing the experiments to the man-carrying stage.

Later, however, encouraged by the appreciation of the War Department, which recognised in the Langley aërodrome a possible new engine of war, and stimulated by an appropriation of 50,000 dollars, he constructed a full-sized aërodrome to carry a man. Two attempts were made, with Mr. Charles Manley on board as aviator, to shoot the machine into the air from the top of a house-boat, but on each occasion the machine caught on the launching ways and was precipitated into the water. The public, not knowing the nature of the defect which prevented the aërodrome from taking the air, received the impression that the machine itself was a failure and could not fly.

This conclusion was not warranted by the facts; and to me, and to others who have examined the apparatus, it seems to be a perfectly good flying machine, excellently constructed, and the fruit of years of labour. It was simply never launched into the air, and so has never had the opportunity of showing what it could do. Who can say what a third trial might have demonstrated? The general ridicule, however, with which the first two failures were received prevented any further appropriation of money to give it another trial.

Conclusion.

Langley never recovered from his disappointment. He was humiliated by the ridicule with which his efforts had been received, and had, shortly afterwards, a stroke of paralysis. Within a few months a second stroke came, and deprived him of life. He had some consolation, however, at the end. Upon his death-bed he received the resolution of the newly formed Aëro Club of America, conveying the sympathy of the members and their high appreciation of his work.

Langley's faith never wavered, but he never saw a man-carrying aërodrome in the air. His greatest achievements in practical aërodromics consisted in the successful construction of power-driven models which actually flew. With their construction he thought that he had finished his work, and in 1901, in announcing the supposed conclusion of his labours, he said:—

"I have brought to a close the portion of the work which seemed to be specially mine—the demonstration of the practicability of mechanical flight—and for the next stage, which is the commercial and practical development of the idea, it is probable that the world may look to others."

He was right, and the others have appeared. The aërodrome has reached the commercial and practical stage, and chief among those who are developing this field are the Brothers Wilbur and Orville Wright. They are eminently deserving of the highest honour from us for their great achievements.

I wish to express my admiration for their work, and believe that they have justly merited the award of the Langley medal by their magnificent demonstrations of mechanical flight.

INDUSTRIAL ENGLAND IN THE MIDDLE OF THE EIGHTEENTH CENTURY.

THE conditions of the chief industries of the country at the date (1754) when the Society of Arts was founded were surveyed by Sir Henry Trueman Wood in an elaborate paper read by him at a meeting of the society on April 20. In the middle of the eighteenth century England was not to any noteworthy extent a manufacturing country, the most important industry being agriculture and occupations relating to it. At the epoch to which the paper refers, however, an industrial revolution was beginning which transformed England from an agricultural country, with no manufactures beyond those required for the supply of its own population, into the workshop of the world. Sir H. T. Wood described the positions of industries concerned with wool, cotton, linen, silk, various metals, brewing, distilling, tanning, paper, printing, and many other arts. From the mass of historical material brought together in the paper a few extracts are subjoined upon subjects associated with science. The retrospective view which these extracts provide is of interest to students of the progress of science and industry.

Science.

Science, about the middle of the eighteenth century, was not in a condition of active progress either in England or abroad. The time was not, either for science or scientific men, a happy one. International intercourse was impeded by wars; national progress was hindered by political differences. The great days of Newton, Hooke, Boyle, and Halley were past. Those of the founders of modern science were yet to come. Cavendish had just left Peterhouse. Priestley had not yet turned his attention to natural philosophy—his scentific work began in 1758. Banks, who ruled the Royal Society for so many years, was in 1754 a boy of eleven. Gilbert White (b. 1720) commenced his "Garden Kalendar" in 1751, but he did not make Pennant's acquaintance until thirteen years later, when he started the famous correspondence which formed the groundwork of the immortal "Natural History of Selborne." Franklin had completed and made public his

epoch-making experiments, and (in 1752) proposed to protect buildings by the lightning-rod. Black, the friend of Watt, and the enunciator of the principle of "latent heat," produced his first important work as a thesis for his M.D. degree in 1754.

In the earlier part of the century the power of mathematics in enabling us to grapple with the most abstruse problems of nature was first clearly demonstrated. In the latter part the foundations were laid on which the modern science of chemistry was built. The intervening years were not characterised by any marked progress in abstract science.

The Royal Society (to which a charter had been granted in 1662) was now firmly established at the head of British Science. Though it was still deemed a suitable object for the occasional shafts of humorists, and though it was sometimes attacked by quacks whose pretensions it declined to countenance, it was recognised and respected by all serious students of science at home and abroad. It had gathered to itself the best thought of the country, and was affording to what would otherwise have been the isolated efforts of scientific pioneers the advantage of coordination and cooperation.

Scientific attention was then principally, though by no means exclusively, directed to astronomy and to exploration. The transits of Venus of 1761 and 1769 had been predicted by Halley, and great importance was attached to their proper observation. An Act of 1743 offered a reward of 20,000*l.* for the discovery of a north-west passage, and later the discoveries of Captain Cook received full scientific recognition by the award of the Copley medal.

Perhaps no better indication of the state of scientific progress at any time in England could be found than is provided by the list of the Royal Society's Copley medallists. In 1731 and 1732 the medal was awarded to Stephen Gray,[1] the ingenious electrician who contrived a method of sending signals by means of frictional electricity, and who made, therefore, the first electric telegraph. It must, however, be added that the award seems to have been rather in the nature of acknowledgment of a skilful experiment than of appreciation of an important discovery. Bradley received the medal in 1748 for his discovery of the aberration of light, and Harrison in 1749 for his chronometer. In 1753 it was given to Franklin for the lightning-rod, and in 1758 to Dollond for his achromatic telescope.

The nature of these last three awards shows the tendency of the time towards practical rather than towards abstract science, and justifies the conclusion that the leaders of scientific thought of those days were working rather for practical results than for the advance of theoretical knowledge.

Iron.

The history of the origin and growth of the iron manufacture in England has been often told. The first step in its progress was the substitution of coal for wood charcoal in the process of reducing the metal from its ores. In the ironworks of Sussex and elsewhere the iron was made on open hearths, or small furnaces, by the help of bellows worked by hand or water. In early times the natural force of the wind was utilised, which, as an early writer says, "Saveth the charge of the bellowes and of a milne to make them blow."

In such furnaces, with their moderate temperatures, uncoked coal could not be used, and the sulphur and other components of the coal affected the product injuriously. Nevertheless, numerous efforts were made—more or less successfully—to use the cheaper and more abundant fuel, and but a very few years before the special date with which we are concerned, the new method may be said to have been placed on a commercial footing.

It was at Coalbrookdale,[2] in Shropshire, that Abraham Darby established the manufacture of iron by coal about 1730 or 1735. He treated the coal as the charcoal-burners treated wood, and found that in the resulting coke he had the fuel he required. In 1754 he had some seven furnaces (presumably small blast furnaces or reverberatory furnaces), and for blowing these he had five "fire engines" (steam or atmospheric engines), which pumped water to drive water-wheels which worked the bellows, the "rotative" engine not having then been invented. Such was the point that the manufacture of iron had reached at the time about which we are concerned. A few years later, in, or shortly after, 1760, Dr. Roebuck used blowing engines at the Carron Iron Works in Stirlingshire. These had four single-acting cylinders of cast-iron 4 feet 6 inches in diameter, and the pistons, of which the stroke was 4 feet 6 inches, were worked in alternation, so that a continuous and tolerably equal blast was maintained.[1] They were constructed by Smeaton.

It was the father of this Abraham Darby, Abraham the elder, who introduced into England about 1706 the art of casting iron vessels. The story, old and well known as it is, will bear re-telling. Early in the century John Darby brought over some Dutch brass-founders, and set up a foundry in Bristol. Here he tried to make iron pots instead of brass, but failed, until his Welsh apprentice, John Thomas, "thought he saw how they had missed it," tried the experiment, and, working secretly with Abraham Darby (the son of John), cast the same night an iron pot. "For more than 100 years after the night in which Thomas and his master made their successful experiment of producing an iron casting in a mould of fine sand, with its two wooden frames and its air-holes, the same process was practised and kept secret at Colebrook Dale, with plugged key-holes and barred doors."

It is about this date (1740, or a little later) that Huntsman perfected the process of making cast steel, which is still employed. Before this, "Steel was never melted and cast after its production." "By whatever method prepared, whether by the addition of carbon to malleable iron, or by the partial decarbonisation of pig iron . . . steel in mass was never obtained homogeneous." There is no need to describe the process, with its purely technical details. It may be sufficient to record the fact that the problem of producing ingots of steel of uniform composition was solved by Benjamin Huntsman, and that, as his secret method of working was stolen by a workman, it soon came to be generally employed in the Sheffield steel trade.

These early founders of the great British iron trade were soon followed by many others, chief of whom was Henry Cort with his invention of puddling (1783), and the manufacture, stimulated, in the later days of the century, to meet the rapidly growing demand for iron caused by the development of machinery and the steam engine, soon reached a most important place among the industries of the country.

Copper and Brass.

Without considerable research it might be difficult to give anything like a trustworthy account of the condition of metalliferous mining and metallurgy in the middle of the eighteenth century, and even if the labour were undertaken it would be difficult to ensure accuracy of result. Copper, tin, and lead have been mined and smelted in Great Britain from very early dates. Zinc, in the metallic state, was imported from China (or, at all events, from the East) in the early part of the seventeenth century,[2] but it does not seem to have been made in England until a century later.

Percy, while he professes himself unable to give a complete history of copper-smelting in England, tells us of early copper-mines in Cumberland and Northumberland, and thinks that the ores were smelted on the spot; but copper was imported from Hungary and Sweden, while calamine (zinc carbonate) was allowed to be exported as ballast. About the end of the seventeenth and the beginning of the eighteenth century copper-smelting was being carried on in Yorkshire and Lancashire, also a little later in Cornwall, in Gloucestershire, and at Bristol. The date of the establishment of copper works at Swansea (now the centre of the trade) is given as 1720, though Percy states that smelting was carried on in the Principality before that date. Brass (an alloy of copper and zinc), as distinct from bronze (copper and tin), was known

[1] Gray it was who first proposed the theory of positive and negative electricity.

[2] This is the usual spelling. Percy has Colebrook, and gives Coldbrook as the original name.

[1] Percy, "Iron and Steel," p. 889.

[2] Percy's "Metallurgy" (1861), p. 519.

"early in the Christian era, if not before its commencement"; but this was doubtless made, like early bronze, by mixing the ores before or in the process of smelting. By the middle of the century considerable progress had been made in its manufacture. Though brass, native and imported, was known in England long before, it is believed that it was not until the reign of Elizabeth that its manufacture was seriously undertaken. From that time forward a good deal of brass seems to have been made from British ores, and a goodly number of brass articles produced.

Tin.

Tin is certainly the most ancient of British exports. It was mined in this country before Britain was known to the Romans, and was brought by the Phœnicians from Cornwall and Devon, the Cassiterides (tin-lands), far beyond the Pillars of Hercules. For centuries England had what was almost a monopoly in supplying tin to the civilised world, the amount mined in Cornwall and the west of England growing steadily both in bulk and value until the discovery by the Dutch of large supplies of tin in Banka, Sumatra, whence it was first imported into Europe about 1787.

The most important application of tin is to the coating of iron-plate, to produce what is known as tin-plate or tinned plate, and is now popularly termed tin. Until the middle of the seventeenth century this manufacture was not known in England. English tin was exported to Saxony, where it was used to coat plates, which were sent to England. That ingenious projecter and author, Yarranton, found out the German methods, and established a factory in the Forest of Dean, where plates were made better, it is said, than the German productions. It seems likely that the secret lay in rolling out the iron, previous attempts having been made with hammered plates. From this date the manufacture of tin-plate, and the use of rolls for the purpose, appears to have been established in England.

Lead.

The reduction of lead from its ores is a comparatively simple process, and it might not be untrue to say that the process has been rather developed than radically changed from the time when Pliny referred to British lead as used for the manufacture of lead pipes in Rome. Down to some time in the seventeenth century wind was relied upon for feeding the Derbyshire furnaces, which (as in Pliny's time) were placed on high ground to catch the breezes. Later, bellows driven by water-wheels were employed. Cupola furnaces were introduced into Derbyshire from Wales about 1747. These are identical with those now used. Coal was employed for smelting lead in the seventeenth century, there being two patents (1678 and 1690) granted for this privilege.

Coal.

The use of coal for fuel is referred to in a grant of land to the Abbey of Peterborough in A.D. 853. Records referring to the existence of collieries in Scotland go back as far as the end of the twelfth century, and in the thirteenth there is evidence that coal was brought to London by sea from the north. Such coal, besides being used for domestic purposes, was at first used for lime burning, soon after in smiths' forges, and in later times for the smelting of copper and lead, in furnaces for the manufacture of pottery and glass, for drying malt, for making salt, by brewers, and for other industrial purposes.

Curiously enough, many of the earlier references to coal are due to its objectionable qualities. Its smoke and smell were disapproved of, and not without reason. In 1306 there was a Royal Proclamation against the use of coal in London, and there were many complaints about its smoke in later years. As its employment became more popular it became an article of commerce, and in 1563 an Act of Parliament prohibited its export, either in the form of ballast or otherwise. By the middle of the century it was, of course, worked on a large scale. As the shafts of the collieries grew deeper, in the effort to comply with the growing demand, fresh difficulties were encountered. The deepest shaft in 1754 appears to have been that at Whitehaven, which reached a depth of 130 fathoms (or about 800 feet), and this must have been quite exceptional, for probably hardly any coal was worked at a greater depth than 100 fathoms.[1]

Early in the eighteenth century fire-damp began to claim its victims. Its existence had been recognised long before, but very little was known about its nature. There were in the first half of the century several serious explosions with a considerable loss of life. The earliest effort to improve matters by ventilation was made about 1732, when the first attempt was made to produce a draught by means of furnaces. Between that date and 1754 considerable improvements were made in ventilation, and at that time, or a few years later, something like the modern system had been introduced by Spedding.

The great danger connected with fire-damp was, of course, the use of naked lights. From the earliest times lamps and candles were employed, and miners had got to be very expert in detecting the presence of fire-damp by the use of the latter.[2] When it was found that the use of naked lights was dangerous, attempts were made to provide a light which would not fire the inflammable gas. The best of these was the "steel mill," the date of which is probably somewhere between 1740 and 1750. This apparatus was introduced by Spedding in consequence of some experiments by Sir James Lowther, which seemed to show that fire-damp was not ignited by sparks from a flint and steel. It consisted of a steel disc rotated by hand, against which a flint was held. The result was a shower of sparks, which gave a very faint, dim light, and for long it was erroneously believed that the apparatus was not capable of firing the gas. Nothing better, however, was known until Dr. Clanny's lamp in 1812, the precursor of the safety lamps of Davy and Stephenson.

Another great difficulty—perhaps the greatest felt by the miner—was that of keeping the mines free from water. From the early part of the century Newcomen's steam, or rather atmospheric, engine had been successfully used for this purpose, all other attempts at pumping having been found quite unable to deal even with the short shafts then existing.

In the earliest coal mines the mineral had been raised to the surface by men climbing ladders, or in baskets worked by horse-gins; but the successful use of the steam engine for pumping suggested its application to haulage, and about 1753 attempts were being made to apply it to this purpose. In the earliest of these "a basket of coals was raised by the descent of a bucket of water, the steam engine being employed to re-pump the water to the surface."[3]

Later in the century the hardly less clumsy method was employed of pumping water to a height and causing it to work water-wheels, which served to wind the coal to the surface. This roundabout and costly device was coming largely into use, when the application of the crank to the steam engine enabled the necessary rotation of the winding drum to be obtained direct from the engine.

Glass.

From a very early date glass had been manufactured in many places in England, and on a considerable scale. Most of this early glass was inferior, greenish in colour, and principally used for windows, though drinking-vessels of tumbler shape were also produced of the same material.[4] At the date with which we are dealing large amounts of this same glass were being made in London, Newcastle, Birmingham, and elsewhere.

The materials employed were sand or "rock" (ground sandstone) and a crude alkali obtained from the ashes of plants. In this country the best alkali was obtained from burning kelp, and the collection and burning of that plant was a considerable industry on the coasts of Ireland and Scotland until the discoveries of Leblanc in 1792 enabled salt to be converted into carbonate of soda, and so put an end to the treatment of ashes for the potash and soda they contain. For making the commonest sort of green glass for glazing purposes the ashes of various plants were

[1] Wills' Cantor Lectures on "Explosions in Coal Mines" (1878), Journal of the Society of Arts, vol. xxvi., p. 458. Galloway, "History of Coal-mining."
[2] Wills, Cantor Lecture, Journal, vol. xxvi., p. 474.
[3] Galloway, "History of Coal-mining."
[4] Hartshorne, "Old English Glasses" (1897).

employed, fern being one of the most common. The ashes of kelp were not only rich in alkali, but contained a large proportion of lime, which was a necessary ingredient.

The best alkali, known as barilla, soda of Alicante, &c., came from the East, and was produced by burning kali (hence, of course, the name of alkali) plants of the genus Salicornia, or glass wort. This Eastern alkali was certainly used in Venice, Bohemia, and France, and perhaps it may have been imported here also for the better sorts of glass. Saltpetre, either imported or obtained from accumulations of animal and vegetable refuse (nitre-heaps), was also occasionally used. The use of manganese for improving the colour of the glass was well known.

The most important feature, however, of the English glass manufacture in the middle of the century was certainly the production of what is still known as "flint" glass, and was at the time also commonly called "cristal" or "crystal." This was far whiter and more brilliant than any glass which could then be made by other methods. It was employed chiefly for making drinking-vessels, but also for mirrors. The name "flint" arose from crystal glass having originally been made from crushed flint, which provided a nearly pure form of silica. The so-called "flint" is really a lead glass. The best authorities seem to hold that the use of lead was first proposed in England some time in the seventeenth century, though neither the name of the inventor nor the precise date of the invention is known.[1]

Nesbitt thinks the glass-works established by Sir R. Mansell near Newcastle under his patent of 1614 owed their success to the use of lead, and it seems that England had for long a practical monopoly of the manufacture. Hartshorne quotes a French writer as his authority for the statement that in 1760 English flint-glass makers sent four-fifths of their output abroad, the whole of France being supplied with flint glass from England.

Watch-making.

During the eighteenth century the art of horology reached a high level in this country. Tompion, "the father of British watch-making," died in 1713, but his friend and successor, Graham, lived until 1751. Both were buried in Westminster Abbey. Graham invented the mercurial pendulum for compensating variations of temperature, and described it before the Royal Society in 1726. The lever compensation pendulum, acting by the different expansions of brass and steel, and commonly called the "gridiron pendulum," was invented by John Ellicott about 1735. In 1728 John Harrison showed his first chronometer to Arnold, who gave him the good advice that he should go back home into the country and perfect it. This he did, and in 1735 he brought it up to London again to enter it in competition for the reward offered by an Act of Parliament passed in 1714, which promised 10,000*l.* to the inventor of a chronometer capable of determining, within certain limits of accuracy, the longitude of ships at sea. The following year (1736) the Board of Longitude gave him 500*l.* after an experimental voyage, and in 1761 the chronometer was more completely tested by a voyage to Jamaica, when the Board awarded Harrison the full prize, though he did not get paid the whole of it until 1769. In 1749 he received the Royal Society's medal. Mudge (1715–94) and Arnold (1734–99) improved Harrison's chronometers, and practically brought them to their present form.[2]

Many of the clocks and watches made by these and other skilled mechanicians of the period are still keeping good time, and the work of these men, though sometimes a little lacking in finish, will bear comparison, not only with that of their contemporaries in other countries, but with that of any who have succeeded them.[3]

Salt.

In mediæval England salt was important rather as a food preservative than as a condiment, as it provided the only known means of keeping meat and fish in an edible condition. As Thorold Rogers points out,[1] for five or six months in the year the majority of people lived on salted provisions. They had to eat salted meat or go without meat at all. In Lent everybody had to live on salt fish—an unwholesome diet, which was a fruitful source of disease. The salt, which was always more or less impure, and often dirty, was originally obtained from sea-water all round the coast, evaporated first by solar heat and afterwards by fuel. The manufacture of salt was among the earliest applications of coal. The process was carried out sometimes in pans or ponds with clay bottoms, but in later years in metal evaporating pans heated by coal. Sussex, Devonshire, Shields, Bristol, Southampton, all had large salt works. From the southern coasts salt was exported to France, whence, centuries before, when the manufacture had depended on the heat of the sun, it had been imported.

The brine springs at Droitwich were certainly utilised before the early part of the eighteenth century. The salt-bearing strata at Northwich are said to have been discovered in 1670 in the course of boring for coal.

It is to be remembered that the idea of making soda from salt, the foundation of all modern chemical industry, had not yet been realised, though it was perhaps in the air. A little later Roebuck, the friend of Black and the associate of Watt, who was the founder of the great Carron works in Scotland and the first maker of sulphuric acid on a commercial scale, ruined himself by various speculations, amongst which was one for making soda from salt.[2]

Saltpetre.

Saltpetre or nitre (nitrate of potash) was a very important product, since it was a principal ingredient in the manufacture of gunpowder. It was also used in glass-making and for other purposes. It was first imported from the East, India and Persia. It was made in England and elsewhere in Europe, where it does not occur as a natural product, in "nitre heaps." These nitre heaps were composed of mixtures of animal excrement with wood ashes and lime. The process dates from the time of Elizabeth, when a German named Honrick discovered to the Queen for a sum of 300*l.* the secret of making "artificial saltpetre." The heap was watered with urine, and after a sufficient time the material was lixiviated, and the salt crystallised out. As time went on, native saltpetre was imported in considerable quantities, and the need for the strenuous search for saltpetre materials passed away, but much was obtained from the nitre heaps at the date with which we are concerned.

Gunpowder.

The earliest English gunpowder mills were those established at Long Ditton, in Surrey, by George Evelyn (John Evelyn's grandfather) about 1590. Another very important powder factory was that at Chilworth, established about 1654 by the East India Company, or leased by them about that time.[3] This changed hands several times, was flourishing in the middle of the eighteenth century, and is still at work. There were also mills at Dartford and at Battle, in Sussex. Defoe tells us that the best powder in the country was made at Battle. The materials, saltpetre, charcoal, and sulphur, in the same proportions as in modern black powder, were crushed in mills driven by water-power, pestles being used, and later stones. The Waltham Abbey mills, started early in the seventeenth century, were purchased by Government in 1787. The method of manufacture remained unchanged from a very early date until quite recent times, and until the introduction of modern powerful explosives.

Copperas.

Copperas (green vitriol, or sulphate of iron) was made at many places in England, and was a product of considerable importance. It was used in the manufacture of ink, in dyeing, and as a source of sulphuric acid (oil of vitriol). A certain amount of it was obtained in the manufacture of alum from shale, but the bulk of it was

[1] Nesbitt, "Glass Vessels in the South Kensington Museum" (1878); Hartshorne, "Old English Glasses"; "Encyclopædia Britannica," &c.

[2] F. J. Britten, "Former Clock and Watch-makers" (1894).

[3] The clock in the meeting room of the Royal Society of Arts was presented to the society in 1760 by Thomas Grignon (1740–84), a clockmaker of considerable reputation in his time. It is still an admirable time-keeper, and seems none the worse for its hundred and fifty years' service.

[1] "Six Centuries of Work and Wages," vol. ii., p. 95.

[2] Smiles, "Lives of Boulton and Watt," p. 152; "Industrial Biography p. 135; "Dict. Nat. Biog.," Roebuck.

[3] "Victoria County Histories (Surrey)," vol. ii., p. 318.

obtained from iron pyrites. The pyrites (sulphide of iron), or "gold stones," as it was termed, was stacked in heaps and allowed to weather. The drainings from the heap were boiled, with some iron added, and evaporated, the sulphate of iron crystallising out. There were important and old-established works at Deptford, Rotherhithe, and Whitstable. About 1754, works were established at Wigan.

Sulphuric Acid.

Sulphuric acid, known as "oil" or "spirit" of vitriol, was obtained by two processes, both invented by the alchemist Basil Valentine in the fifteenth century. In one of these crystals of sulphate of iron ("copperas") were distilled in earthen retorts, the resulting oil of vitriol being condensed in glass or earthenware receivers. The process is still employed at Nordhausen, in Saxony, and Nordhausen, or "fuming" acid, is still an article of commerce. It differs slightly in its chemical composition from the ordinary modern acid. The second process is the original form of the modern method. In it sulphur was burned under a bell-jar over water, and the acid liquor evaporated. Valentine also burnt a mixture of sulphur, nitre, and antimony sulphide in the same way, and this was an important improvement. About the middle of the eighteenth century a French chemist found that the antimony was not needed, and considerable amounts of the acid were then made.

Up to the middle of the eighteenth century all, or nearly all, the oil of vitriol made in England was made by the distillation of copperas, but in 1740 Ward introduced its manufacture by the method of burning sulphur and saltpetre. In 1749 he obtained a patent for the process. He set up works for making the acid, first at Twickenham and afterwards at Richmond. Dr. Roebuck improved on the process by substituting lead chambers for the glass receivers, and by this important modification the evolution of the modern method was practically completed. Roebuck and his partner, Garbett, first used their improved system in 1746 at Manchester, and in 1749 they set up work at Preston-Pans, near Edinburgh. This invention revolutionised the industry, greatly lowered the cost of production, and, among other applications, enabled the acid to be used for bleaching instead of the sour milk previously employed.

The method used at the present day for the manufacture of the vast quantities of sulphuric acid now required is really only a development of Roebuck's. The principle is the same, though it has been changed by chemical knowledge from an empirical manufacture to a highly scientific process. Iron pyrites (sulphide of iron) has generally replaced the sulphur first used, details have been improved, and the methods rendered more economical, but it remains in its essential features almost identical with that of a hundred and fifty years ago.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—An exhibition of 50*l.* a year, tenable for two years, is offered by the governing body of Emmanuel College to an advanced student commencing residence at Cambridge as a member of Emmanuel College in October. The exhibition will be awarded at the beginning of October. Applications, accompanied by two certificates of good character, should be sent to the Master of Emmanuel not later than October 1.

The chairman of the special board for biology and geology gives notice that applications to occupy the University's table in the Zoological Station at Naples, or that in the laboratory of the Marine Biological Association at Plymouth, should be addressed to him (Prof. Langley) on or before Thursday, May 26.

It is proposed to appoint a syndicate to consider the financial administration of the various scientific departments of the University and the financial relations between these departments and the museums and lecture rooms syndicate; that the syndicate confer with the financial board, the general board of studies, the museums and lecture rooms syndicate, the heads of the various scientific departments, and such other bodies or persons as they may think fit; and that they report to the Senate before the end of the Lent term, 1911.

At the Congregation to be held at 2 p.m. to-day, April 28, it is proposed to confer the degree of Doctor of Law, *honoris causa*, upon Colonel Theodore Roosevelt.

PROF. SENIER delivered a lecture on March 9 last before the Royal Dublin Society on "The University and Technical Training," which has now been published by Mr. Edward Ponsonby, of 116 Grafton Street, Dublin. The lecture formed the subject of a note in our issue of March 24 last (vol. lxxxiii., p. 118).

MR. MILTON C. WHITAKER, general superintendent of the Welsbach Company's works, has been appointed professor of industrial chemistry at Columbia University, to the vacancy caused by the retirement of Prof. Charles F. Chandler. Dr. Marston Taylor Bogert has been appointed to succeed Dr. Chandler as head of the department of chemistry.

THE annual conference of the Association of Teachers in Technical Institutions will be held this year at Birmingham on May 16–17. Among the subjects for discussion are technical universities, relation of evening continuation schools to technical institutions, registration, superannuation of technical teachers, &c. An address will be given by Mr. Cyril Jackson, chairman of the Education Committee of the London County Council, on the extension of day technical work, and a paper will be read by Dr. T. Slater Price on the relation of technical institutions to universities.

THE second International Conference on Elementary Education is to be held at the Sorbonne, Paris, on August 4–7. It is being organised by an International Bureau, consisting of representatives of the various associations of teachers throughout Europe. Among the subjects to be discussed by the conference may be mentioned the aim and object of elementary science teaching in primary schools; compulsory attendance; the professional training of teachers, inspectors, and educational administrators; and educational continuation work. Further information may be obtained from Mr. Ernest Gray, 67 Russell Square, London, W.C.

IN connection with the appeal for 70,000*l.* for the purchase of a site and the erection of new chemical laboratories thereon at University College, London, to which we directed attention in the issue of NATURE for February 17 (vol. lxxxii., p. 462), the Lord Mayor has arranged a meeting of city men to be held at the Mansion House on May 10, at 4 p.m. The chair will be taken by the Lord Mayor, and the following gentlemen will speak:—the Earl of Rosebery (Chancellor of the University), the Earl of Cromer, Lord Avebury, Sir Felix Schuster (treasurer of University College), Dr. Miers (principal of the University), Sir Henry Roscoe (chairman of the appeal committee), and Sir William Ramsay, K.C.B.

THE attention of the Chancellor of the Exchequer was directed on April 22 in the House of Commons to the grave difficulty experienced by local education authorities in respect of the grant for secondary education based on the reduced amount of the "whisky money" for the present year. The amount received by local education authorities for higher education under the Local Taxation (Customs and Excise) Act has become greatly diminished, and many authorities have had to consider the question of reducing their work for next year, particularly in regard to evening classes. As was pointed out in the House by more than one speaker, it is highly unsatisfactory that the grant for higher education should depend upon the consumption of whisky in the country. The Chancellor admitted that something ought to be done in the course of this year to put the revenue of these local authorities on a more dependable basis. He said the loss owing to the decrease in the whisky revenue was 253,000*l.*, and he suggested, on behalf of the Government, that half the land taxes—which, it is expected, will be, in respect of last year, 490,000*l.*—shall be allocated for the purpose of making good the deficiency; and, secondly, that the