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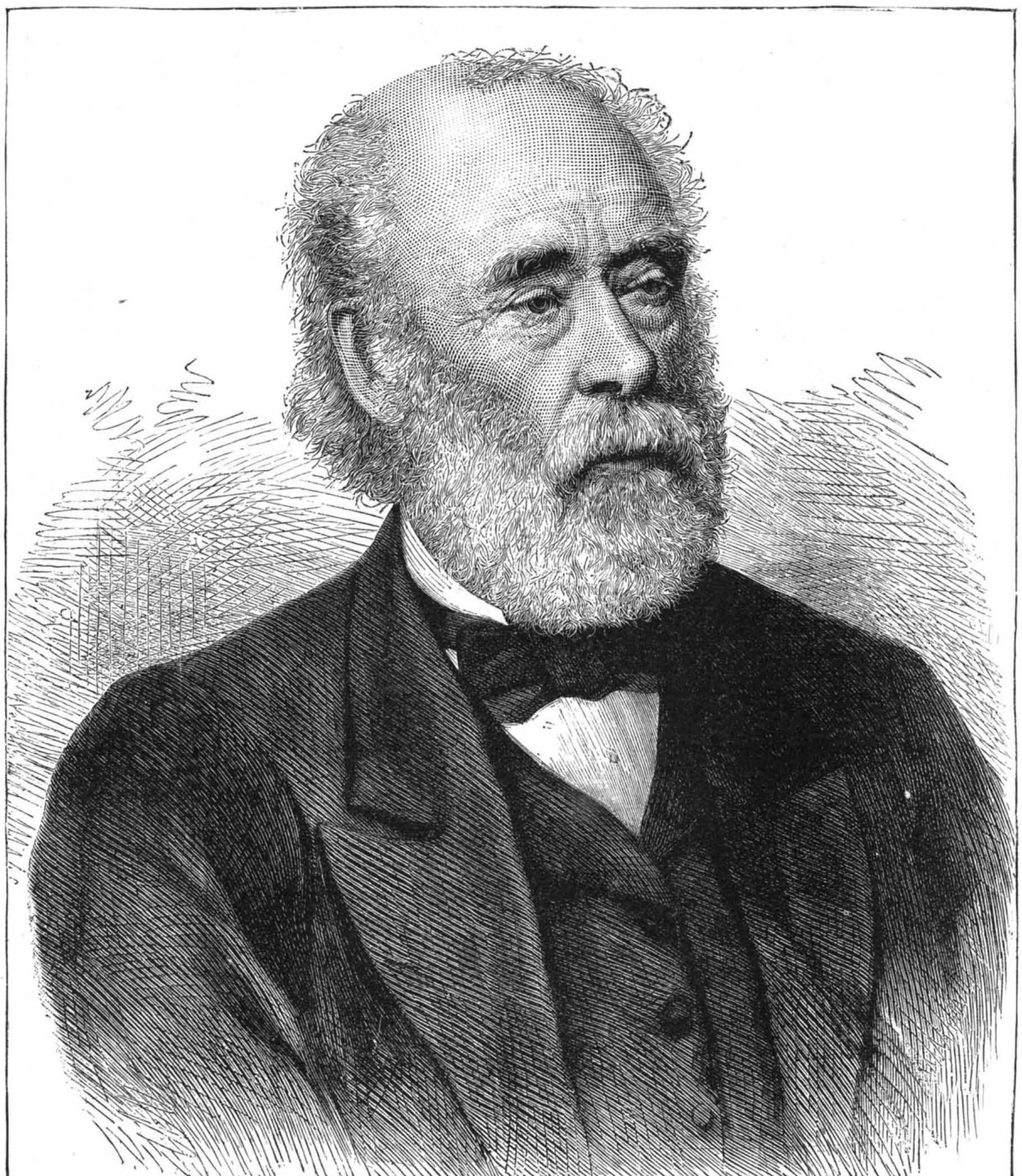
By the death of Sir Joseph Whitworth, which occurred January 22, we lose almost the last of the giant race of mechanics who, in comparatively few years, raised this country to that supreme position in the manufacturing arts which was demonstrated at the great exhibition of 1851. At that date the name of Whitworth was already stamped on engineering practice too deeply to be erased, and was the symbol of a system which has since spread over the world, and contains the essential principle of all profitable mechanical enterprise. It would be impossible to find a workshop which has since earned celebrity for its manufactures and brought wealth to its proprietors in which the methods originated by Whitworth, and ceaselessly preached by him, are not rigorously carried out; and, on the other hand, it would be easy to point to the failure of many established firms who neglected the lessons he taught, and paid the penalty of their ineptitude in their ruin. Sir Joseph Whitworth was a brilliant example of a man possessed of that penetration which grasps fundamental principles, and then never wavers in his faith or shrinks from the proclamation of his creed. He found the mechanical world without law or order; every one did that which was right in his own eyes, selecting his own standard, and following it as closely or as loosely as he pleased. Scarcely two standards were alike, and, even if they were, it by no means followed that the work done to them corresponded. The result was confusion and waste—waste of time, waste of material, and waste of money. Whitworth perceived that the cure of this lay in the production and acceptance of universal standards of measurement, and in accurate workmanship which should render objects of professedly similar dimensions alike within certain determined percentages of error. The whole of the earlier part of his career was devoted to means for carrying out and popularizing this idea, while the work of his later years was built upon it. He saw that the cheapest production and the most accurate workmanship went hand in hand, and that commercial and scientific principles alike demanded the same methods of construction. He took the "true plane" as his starting point, both actually and figuratively, and was never tired of insisting upon its fundamental importance. To many of the present generation of engineers his utterances on this subject bore the appearance of platitudes, and seemed as lacking in originality as would the reiteration of the commandment "Thou shalt not steal" to a lawyer. But both in mechanics and morality there is a tendency to neglect fundamental principles, and the world is the better for being reminded of their existence from time to time.

It is not to be supposed that Whitworth was the first to perceive that accuracy and interchangeability were the essential features of successful engineering practice. Among his predecessors and contemporaries there were many able mechanics who must have felt the evil of the unsystematic processes then in vogue, and have comprehended how they should be remedied. But the task was too great to be attempted by any man who had not both a genius for mechanics and a stubborn strength of will founded upon a perfect conception of the truth of his convictions and an absolute faith in their final acceptance by the public. Such work as this cannot be done by the mere inventor—the man of ingenuity and happy resource—but is the outcome of the philosophic mind, which, by its analytical power, tears off and discards the external and accidental aspects of a question, and demonstrates its elementary constitution. This was the characteristic of Whitworth's method of procedure. He conceived an ideal perfection, and set himself to attain it. Having thought each matter out until he arrived at what appeared to him as finality, he listened to no suggestions of compromise or alternative. He knew that he was right, and started off on the track he had discovered, leaving others to follow as they would. The result justified his confidence, and time brought him his revenge over many detractors. His true plane and his standard measures are found in every engineer's shop in the world. His screw threads are universally known, and are used in many countries. The principles of gunnery which he laid down in 1857 are now the alphabet of the science, although they were as a foreign tongue to the experts of the day. His compressed steel is the ideal metal to which constructors turn in their difficulties. In a word, the tasks which Whitworth attempted he accomplished, and in almost every instance he lived to see the triumph of his ideas.



SIR JOSEPH WHITWORTH, M.E.

The tale of Whitworth's production of his first true plane has often been told both by himself and others, but is too characteristic to be omitted. When working at Maudslay's, where he occupied a place in the private workroom of his master, it struck him that if two true surface plates were placed face to face, they should adhere. The fact that they did not proved to the young mechanic that the method of manufacture was faulty, so he set to work at his lodgings to produce three plates by the now well-known method of scraping. He was entirely successful, and found his immediate reward in the admiration of his fellow workmen. His pecuniary recompense was to come later, when his self-appointed period of education was completed. It must be remembered that the subject of our memoir did not become a mechanic either by necessity or accident. His father, Charles Whitworth, of Stockport, was in comfortable circumstances as the proprietor of a large day and boarding school, and was able to send his son, at the age of twelve, to have his education completed under Mr. Vint, at Idle, near Leeds. After a year and a half spent there, the boy went to his uncle in Derbyshire to learn the business of a cotton spinner. Here he stayed four years, and to all appearance might have remained permanently, as he had for some time filled the position of manager, had he not determined to devote himself to the manufacture of machinery. In 1821, at the age of eighteen, he broke the connection with his uncle by the only way open to him, and ran away to Manchester, where he found work at the bench in the shops of Messrs. Crighton & Co. For twelve years afterward he continued this course of life, moving from shop to shop and gathering experience in all the best fields to be found. For four years Whitworth stayed in Manchester, and during that time he marked out a career for himself. He saw that the rapid introduction of steam power was creating an enormous opening for machinery which there was no adequate means of producing, and that the great want of the time was tools. He, therefore, determined to go to London, then the home of all good workmanship, and when he had acquired all the knowledge to be obtained there, to commence the manufacture of machine tools. He worked at Maudslay's, Holtzapffel's, and Clement's, and in 1833, at the age of thirty, he returned to Manchester, set up in Chorlton Street, erecting over his premises the sign "Joseph Whitworth, tool maker, from London."

The years from 1833 to 1854 were devoted principally to the improvement of machine tools, and the records of the Patent Office show that they were spent industriously. During this interval were designed and perfected the whole series of machines which have carried the name of Whitworth all over the Continent. But, before substantial progress could be made in this direction, it was necessary to furnish the workmen with more delicate gauges than they possessed. This led to the production of the system of standards and of the famous measuring machine. These were not mere modifications of existing apparatus, but were founded on a principle which had hitherto not received the recognition it deserved. This was that the sense of touch was capable of detecting differences of size inappreciable to the eye. This fact was, of course, perfectly well known to every mechanic, but had never been made the basis of a system, for by itself it was incomplete. It is not only necessary that a workman should be able to say which of two pieces is the larger, but he must also be able to determine by how much the two vary, and this can only be done by aid of a machine which will magnify the difference to such an extent that it can be taken account of by the sense of vision. For this purpose Whitworth produced his measuring machine, in which, by means of an accurate screw, and an index wheel divided into 500 parts, he could detect differences of 0·00001 in. The striking feature of this appliance was that it did not measure by end contact, but by feeling, for, by moving it through one division, the test-piece was either gripped or allowed to fall, and thus its size was demonstrated within the limit stated. Still more delicate machines have since been made, capable of detecting differences of one millionth of an inch.

The best known and appreciated piece of work which Whitworth did for the engineering world at this time (1840) was the introduction of a uniform system of screw-threads. Before, and for many years after, he took the matter in hand, every large establishment had its own system, and, as there are no exact theoretical considerations which determine the three constituent characters of pitch, depth, and form, it followed that there was great diversity between the different systems, according as their authors regarded strength, power,

or durability as the most important feature. As threads must always represent a compromise between these three qualities, their determination cannot be effected on the general methods which Whitworth usually employed in solving a problem. As an appeal to first principles was out of the question, he proceeded by way of compromise, and to this end he gathered an extensive collection of screw bolts from all the principal English workshops, and from these he deduced the average thread for different diameters. The ¼ in., ½ in., 1 in., and 1½ in. were taken as the fixed points of a scale by which the intermediate sizes were regulated. The only deviation from the exact average was such as might be necessary to avoid the great inconvenience of small fractional parts in the number of threads to the inch. The proportion between the pitch and diameter varies through the entire scale. Thus, at ¼ in. it is one-fifth, at ½ in. one-sixth, at 1 in. one-eighth, at 4 in. one-twelfth, and at 6 in. one-fifteenth. This decrease is not so rapid as it would be if the screws were designed so that a man might tighten any one with equal facility. Practical considerations require that a small bolt shall have a fine thread, and a large one a coarse thread. The variation in the depth, among the different specimens examined in determining the scale, was greater, proportionally, than in pitch. The mean of the angle of the thread in 1 in. screws was found to be about 55 degrees, and, eventually, this angle was adopted all through the scale. This established the well-known constant proportion between the depth and the pitch of the thread, which is between three-fifths and two-thirds. The system was rapidly adopted in many extensive engineering establishments, and in 1841 it was introduced into the Royal Dockyard at Woolwich and into the shops of the Royal Mail Steam Packet Company. Since then it has spread over the whole of the United Kingdom and the Colonies, Russia, Italy, and Germany, and its future extension to all countries which have not already a uniform system appears probable. But in every part of the world the Whitworth thread is known, and screws made to it can be produced.

Up to the year 1854, Whitworth was a toolmaker, but at that date he was diverted into another channel, which brought him little or no profit and endless vexation and annoyance. When we say that he came into contact with the Ordnance Board, every one who has had anything to do with that body will at once understand that he met with difficulties which even he could not vanquish. Indeed, he was not well equipped for the task. His powerful analytical mind, which went right to the heart of a question, never stopping to inquire what was the customary way of treating it, was certain to raise the most active antagonism of officialism. At that time the government service was far more independent of public opinion than it is at present, and even now it is well known that a man must possess wonderfully persuasive powers to enable him to turn it from the even tenor of its way, which it loves so dearly. But Whitworth was no persuader. Demonstration "clear as Holy Writ" he could provide in all abundance, but in the art of backstair negotiation he was a novice, despising both it and those who required it. The tale of his gunnery experiment, therefore, bears a twofold aspect. Considered scientifically, it reveals a brilliant triumph, and displays all the best qualities of the man—his deep thought, assiduous patience, and penetrating intellectual vision. But, from the point of view from which the experiments were made, namely, the immediate introduction of the best military rifle which science could supply, they were abortive, and a source of disappointment to all concerned in them.

The matter arose in this way: The government had decided to furnish the army with the Enfield rifle, and they were desirous of fitting up a factory with machinery for its manufacture. Hitherto all guns had been made to a great extent by hand, and it was a matter of chance whether they turned out good or bad. It would often happen that two rifles made by the same workman, and, to all appearance, alike, would give widely different results, and no one knew in what lay the secret of superiority of the one. This was a very serious inconvenience, and as Mr. Whitworth held the highest position in the country as the maker of accurate machinery, Lord Hardinge applied to him for help in May, 1854. As commissioner to the New York exhibition, Mr. Whitworth had inspected the State Armory at Springfield, Mass., and had reported on the suitability of the machinery he there saw for the manufacture of firearms, and in this way the attention of the government had been directed to the introduction of machinery on a large scale at Enfield. Mr. Whitworth was requested to furnish designs for a complete set of new machinery, but he declined the tempting offer until it had been demonstrated what constituted the difference between a good and a bad rifle. The authorities, unable to detect any difference between similar weapons, had decided that the variations must be due to the machinery by which they were manufactured, and imagined that if the appliances were improved, all the guns would be alike good. But this view did not commend itself to the man who was accustomed to measure to a millionth of an inch, and he refused to lend his assistance unless facilities were first found him to enable him to discover the secret of the correct proportions of a rifle barrel and projectile. The offer was not at first accepted, but, ultimately, at the instigation of Lord Hardinge and the Earl of Ellesmere, a shooting gallery, 1,500 ft. long by 16 ft. wide and 20 ft. high, was built at Fallowfield, Manchester, and in this the experiments were carried out, with the assistance of two military officers and of Mr. Westley Richards.

While the gallery was building, Whitworth turned his attention to the subject of siege guns, to which the operations in the Crimea gave a special interest. He constructed a rifled cannon, cast in longitudinal segments, in each of which the line of junction followed the course of the spiral. These, when placed together, so as to form a barrel of a spiral polygonal shape internally, were secured by hoops of wrought iron applied in layers. A small scale model of a gun on this principle was made, but was not proceeded with, but the idea of the polygonal bore thus produced appeared in the small arms which were made immediately afterward. We cannot follow in detail the course of the experiments which were carried out, and which were conducted in a systematic manner. The first point demonstrated was that if the projectile were lengthened beyond the limit of the Enfield bullet, no disposition of its weight could prevent it turning over with the rate of rifling then in vogue, that is with one turn in 78 in. A series of barrels with quicker rifling, giving every gradation down to one turn in 5 in., were made, and it was found that the best average was obtained with one turn in 20 in. At the same time, the length of the bullet was fixed at 3 to 3½ calibers. The lessons taught by the investigation were that the secret of accurate shooting lay in an improved system of rifling, viz., a turn in the spiral four times greater than the Enfield rifle; a bore one-fifth less in diameter; an elongated projectile capable of a mechanical fit; and, lastly, a refined process of manufacture.

The Whitworth rifle was first formally in competition with the best Enfield muskets at Hythe, in April, 1857, with the results given in the annexed table:

Rifle.	Range, Yards.	Elevation, Degrees.	Average Difference of Hits from a Given Center.
			ft.
Whitworth....	500	1·1	0·37
Enfield.......	500	1·32	2·24
Whitworth....	800	2·22	1·0
Enfield.......	800	2·45	4·11
Whitworth....	1,100	3·45	2·41
Enfield.	1,100	4·12	8 04
Whitworth....	1,400	5·0	4·62
Enfield.......	1,400	6·20 to 7·0	no hits.
Whitworth....	1,800	6·40	11·62
Enfield.......	1,800		

This shows that the new arm was immeasurably the superior at all ranges. At 500 yards its figure of merit was six times as good as that of the Enfield; at 800 yards it was 4·11 times; at 1,100 yards it was more than three times, while at 1,400 and 1,800 yards the Enfield piece was useless, and, therefore, no comparison could be made. Other trials against the arms of private makers followed with similar results (see table), and

Competitors.	Mean Figures at 500 Yards.	Mean Figures at 1,000 Yards.	Mean at Both Ranges.
	ft.	ft.	ft.
Whitworth.......	0·57	1·77	2·34
Baker............	0·65	2·86	3·51
Turner........ ...	0·74	2·85	3·59
Parsons........ ..	0·75	2·47	3·22
Bissell...........	0·87	3·34	4·21
Aston......... ...	0 91	3·32	4·23

everything appeared ready for the adoption of the rifle. But neither the weapon nor the inventor complied with the red-taped ideas of the military authorities, who were now no longer under the control of Lord Hardinge, and a committee reported that the bore of the Whitworth rifle was too small for a military weapon. This decision seems to have been based on the idea involved in the Irish difference between "kilt" and "kilt intoirely," for it is impossible for any ordinarily constituted mind to understand what difference it can make whether his enemy be killed with a small bullet or a large one.

It is difficult to conceive what must have been the disgust which filled the mind of Whitworth when he found his years of toil dismissed with this puerile objection. The wonder is that he did not throw up the entire subject of arms, and address himself to matters which would be judged by men of reason. But although he was denied his just recognition, the principles he had discovered found root, and in 1862 another committee reported that "the makers of every small bore rifle having any pretensions to special accuracy have copied to the letter the three main elements of success adopted by Mr. Whitworth, viz., diameter of bore, degree of spiral, and large proportion of rifling surface." Again, in 1869, a special committee recommended that the caliber of the breech loading rifle should be 0·45 in., the exact dimension adopted by Whitworth in 1857 and condemned by the committee in 1859.

Whitworth's experiments with small arms led him forward to the construction of cannon by a very easy step, for the same principles applied to both, and consequently his large guns, at least at first, were built on the same lines as the rifles. At first some brass field pieces were rifled, and in 1858 a 68 pounder cast iron rifled gun fired a solid shot through a 4 in. armor plate fixed to the side of H.M.S. Alfred. This was the first instance in which armor plates were completely penetrated. In 1862, again, a flat fronted steel shell from a Whitworth gun went through 4½ in. of armor and 18 in. of teak, representing the side of the Warrior. Again and again after this date these weapons beat all others, and raised the expectation that they would be introduced into the service, but no amount of demonstration appeared to convince the authorities. In the contest with the Armstrong guns the victory was unmistakably with Whitworth, yet his opponent reaped all its fruits. The subsequent trials at Southport were a revelation in gunnery, and created surprise all over Europe from the distance to which the projectiles were thrown and the small area in which they fell. But it was all to no purpose. The "Woolwich ring" was omnipotent and would brook no interference. It was in vain that Whitworth discounted all their achievements and kept ahead of them in spite of the fact that they had unlimited resources, while he had only a small market in South America. Still they always managed to hold him at arm's length until last year, when, in consequence of strong external pressure, a director of the Whitworth Company was requested to join the ordnance committee, and give the government the benefit of his experience. The whole record of these gunnery experiments is a source of shame to us as a nation, and a scandal to our administration. The Whitworth guns were possibly not perfect, but it is certain that they were immensely superior to the weapons existing at the time, and that, if they had been adopted, their faults would soon have been remedied under the combined action of the inventor and the authorities. What a different position we should have been in to-day if wiser counsels had prevailed! The whole of our armament would have been of steel of the best quality, instead of being of a practically obsolete material, and we should have headed the nations of Europe in the matter of artillery, instead of being the worst armed of any.

Whitworth's artillery experiments demonstrated to him the urgent need of a better metal than was available at the time. High carbon steel was too treacherous a material to be used for his purpose, while mild steel was unsuitable on account of the numerous blow-holes which existed in it. Other artillerists at Woolwich and Elswick found the same difficulties, and in consequence of them abandoned steel in favor of wrought iron coils. But Whitworth saw that guns must be made of the toughest metal obtainable, and he therefore set himself to eliminate the accidental defects of mild steel, by purging it of the gases which caused the blow-holes. To this end he subjected the molten metal to intense pressure during the time of setting, and thus he produced his celebrated fluid compressed steel. He was not the first to propose, or even to practice, the compression of fluid metal. The Broughton Copper Company had employed the process in their works for twenty years, while Bessemer had patented it for steel in this country, and abroad it had been used at St. Etienne, in France, and at Newberg, in Austria. Indeed, there is scarcely any instance in which Whitworth was an inventor in the legal sense of the word. All his notable productions had been proposed by others. The true plane, the measuring machine, the hexagon rifle with a mechanically fitting projectile, and compressed steel, had all been suggested and discussed by others, and the legal plea of "prior publication" could be urged against his claims to being their author. But there is a wider and more real definition of an inventor than that allowed by the courts of law, and it has been stated by Sydney Smith in these words: "It does not follow that a man is the discoverer of any art merely because he is the first to say the thing, but he who says it so long and so loud and so clearly as to compel mankind to hear him. It is the man who is so deeply impressed with the importance of his discovery that he will take no denial; but at the risk of fortune and fame, pushes through all opposition, determined that what he feels he has discovered shall not perish for want of a fair trial." Judged by this standard, Whitworth may be classed among the great inventive geniuses of this country, and it is only a mean mind that would seek to detract from his fame because the materials out of which he forged his successes were the failures of his predecessors.

But to return to the compressed steel. The rings for the guns were cast in vertical steel moulds capable of withstanding a pressure of 6 tons per square inch on the fluid metal. The mould was lined with longitudinal bars with rounded corners, and inside these was a porous annulus of refractory material. The core was similarly constructed, and when the metal had been run, the whole was subject to hydraulic pressure, which could be varied between 2,000 and 8,000 tons. At first there was an escape of metal past the plunger which entered the mould, but this was rapidly stopped by the chilling of the escaping film, and then the metal took the full pressure. The gases were forced out sideways through the sand, and escaped upward through the interstices of the bars until they reached the upper end of the mould, where they burnt with a fierce flame. So great was the evacuation of gas that, with a pressure of 6 tons per square inch, a cylinder 8 ft. long was reduced to 7 ft. in five minutes. The good quality of the metal soon recommended it for other purposes than guns, and it is now extensively used for the propeller shafts of vessels, for liners of steam cylinders, and for many other purposes. When a pressure of 20 tons per square inch is applied, the ingot is said to need no forging, but with smaller pressures it is forged by hydraulic pressure to its ultimate form. Upon the value of the process impartial evidence is furnished by the Gun Foundry Board appointed in 1883 by the Government of the United States: "The Board was allowed the privilege of carrying on its investigations within the works, where, under orders from Sir Joseph, his representatives exhibited, with explanations, the operations carried on in this unique establishment. It may be distinctly asserted that the experiences enjoyed by the Board during its visit amounted to a revelation. . . . In speaking of the Whitworth establishment at Manchester as unique, and of the process of manufacture at that place as a revelation, reference is specially made to the operation of forging. . . . The system of forging consists in compressing the liquid metal in the mould immediately after casting, and in substituting in the subsequent forging of the metal the hydraulic press for the hammer."

Whitworth's talents were not of that unsatisfactory order which benefit every one but the possessor. He had keen business acumen, and was a splendid judge of character, surrounding himself with men capable of imbibing his spirit and carrying out his ideas. As a result he made money rapidly, and was able to indulge in many pleasures outside of his profession. He was a breeder of shorthorns, and took a great interest in horses, while in later years he spent much time in landscape gardening, a pursuit for which the possession of a miniature mountain adjoining his residence in Darley Dale, Derbyshire, gave him unlimited opportunities. In 1869 he gave the enormous sum of 100,000*l.* to found scholarships for the promotion of mechanical science, and every year 3,000*l.* are distributed from this source among the younger engineers in this country. Such an instance of generosity during the lifetime of the donor is almost unknown, and is remarkable evidence of the public spirit and generosity of the man, while the terms of competition which he proposed, so as to render the prize obtainable both by the artisan and the student, mark the intensely practical form which his ideas took.

The great mechanical, scientific, and philanthropic activity of which we have been able merely to mention the most remarkable features was not without some public recognition. In 1857 Whitworth was elected a Fellow of the Royal Society, and was created LL.D. (Dublin) and D.C.L. (Oxford). In 1867 he received at the Paris Exhibition one of the five great prizes allotted to England. In 1868 he was appointed by

Napoleon III. to the Legion of Honor. In 1869 he was created a baronet.

Sir Joseph Whitworth's first wife, Miss Fanny Ankers, died in 1870, and in 1871 he married Mary Louisa, widow of Mr. Alfred Orrell. For about a quarter of a century he lived at the Firs, Fallowfield, where the well-known shooting gallery still recalls him to the neighbors. His later years were spent at Stancliffe, near Matlock, in the county of his boyhood and early manhood.

SIR JOSEPH WHITWORTH.

SIR JOSEPH WHITWORTH, who died Jan. 22, was eminent as a scientific and practical mechanician, and his name was famous as an inventor of improved rifles and artillery. In 1818, when he was fifteen years old, having been born at Stockport in 1803, he entered the factory of Messrs. Crichton, at Manchester. In 1825 he married, and went to London. Eight years later he returned to Manchester, where he passed the greater part of his life. He became a Manchester tool manufacturer. In 1851 his name came before the public as the inventor of improved planing machines and of mechanical appliances for the manufacture of tools, which had a place in the Great Exhibition of 1851. The Crimean war directed his attention to artillery and its uses in modern warfare. He went into the designing of big guns and projectiles, and effected remarkable improvements in both. In this department he was a formidable rival of Sir William Armstrong, and Whitworth acquired a wide reputation for the construction of guns of extraordinary range and remarkable accuracy. His inventions secured the attention of both our own and foreign governments. The works he began at Openshaw grew to vast magnitude. In 1869 he was created a Baronet. In the same year Sir Joseph Whitworth did the munificent act which will hand his name down to posterity. He devoted the large sum of £100,000 to the foundation of thirty "Whitworth Scholarships" of £100 per annum, tenable for two or three years, for the encouragement of mechanical and engineering science. The Government has since added further incentives to the scientific study of certain branches of engineering. The exhibitions, capitation fees, and grants of money for apparatus gave an impetus to the development of mechanical science, especially in the improvement of ordnance. Besides doing so much in the practical work of engineering, Sir Joseph Whitworth contributed to the diffusion of sound theories on several matters concerning which he was a recognized authority. His "Miscellaneous Papers on Practical Subjects: Guns and Steel," were published in 1873. The honorary degree of LL.D. of the University of Edinburgh was conferred on him five years later. Advancing years compelled him to cease active exertions. Latterly his health showed signs of failing, and he was obliged to spend every winter in the South of France. At Monte Carlo he breathed his last, leaving a reputation second to few in scientific engineering.—*The Illustrated London News.*

DISAPPEARING TURRETS.

Le Genie Civil of January 15th describes a new disappearing turret to be tried shortly at Chalons. The writer (Claude Manceau) observes that certain inconveniences are inseparable from the dome which Major Schumann employs. It is suggested that the joints of the Schumann dome offer weak places, that the bolts are liable, both from shock of discharge and of impact, to fly and cause much injury to the detachment, and that it is impossible to predict what dislocation might be caused by the blow of even a single 21 cm.—8·27 in.—projectile falling vertically on the cupola dome, seeing that at Bucharest the vertical fire failed to strike either cupola. It is considered that Major Mougin, in the mushroom-shaped dome which he has now adopted, has remedied some of the faults of the Schumann construction. Dislocation is rendered less liable to occur, because the dome is jointed in two parallel lines, which is thought much better than the radial form of division, which, it is urged, leaves each shield overhanging and depending for its stability on the support of the contiguous sections. The Mougin cupola will then, it is remarked, resemble that of Schumann in general appearance, but it will differ from it in its principles of construction, seeing that the guns of the latter are attached to their cupola, causing inaccuracy in fire as well as other evils. It is further observed that at Spezia, in 1886, the Gruson turret shield threw off the Krupp forged steel projectiles of proved excellent quality, breaking them up in small fragments. This, it is considered, is in a great measure to be attributed to the profile of the shield, against which the projectiles must strike at an angle more oblique than 45 deg.; but the extreme hardness of the metal is also noticed. The effect of projectiles with flat, or rather slightly concave cupped, points is discussed. These projectiles, advocated by Whitworth and Krupp, have cut like a chipping tool into armor at oblique angles, the case in view being probably that at Buckau, when Ternitz projectiles bit into the surface of a Gruson cupola. It is suggested that an attack with cupped out projectiles would prepare the way for sharp pointed projectiles to enter. At angles over 25 deg., it was generally found at Gavre—as in England at angles over the glancing angle—that a given vertical height received the same protection from a given weight of metal, whether the wall was at an inclination or placed vertically.

The main disadvantage of the cylindrical form then lies in the vulnerability of its sharp top edge and in the distinctness with which so defined a form can be seen. At Cotroceni the latter evil was increased by the fact that the French turret stood on higher ground than the German one—a fact, we may observe by the way, which gave it a great advantage when its glacis plate (*avant cuirasse*) was attacked. The French turret also was painted black, and the German one gray.

M. Manceau concludes that the Bucharest experiments showed that no turret could resist constant artillery fire for a very long period, consequently that it is most desirable to put it under cover, if possible, whenever it is not actually firing. This is what has been done in the design shown in Fig. 1. The cylindrical form has been adopted. The roof is made in one piece. There is little to fear from vertical fire, and the edge of the plate is fitted to the vertical wall in the manner shown in Fig. 1, which, it is thought, favors the throwing off of the projectiles and dispenses with vertical armor bolts.

As to metal, it is thought that the experiments of Cotroceni did not conclusively establish the relative resisting powers of steel-faced and wrought iron shields. On the whole, however, it has been decided to adopt steel-faced plates in the design before us—the machinery for effecting the union of the face and foundation plates being of such power that a high degree of perfection in the weld may be expected.

The interior diameter of the turret will be 4·6 meters (15 ft.). The vertical wall is 1·2 meters high (3 ft. 11¼ in.), consisting of three plates of 50 centimeters (19·69 in.), which are fitted together by tongues and grooves.

The roof plates resting on the wall, as above described, are 20 centimeters (7·87 in.) thick. The whole armored structure rests on a wrought iron structure and trunk, 5 meters in height, comprising two cylindrical portions of 1 and 2 meters, and a conical portion (see Fig. 1). The cylindrical parts slide during the vertical movement of the turret, in two guiding rings. These keep the turret in the vertical position.

The base is supported on the piston of a hydraulic press, 45 centimeters (17·72 in.) in diameter, which constitutes the pivot of the turret which moves on it. The center of gravity falls well over the pivot, and rollers can be dispensed with. The piston is 1·5 meters (4 ft. 11 in.) long, the movement being 1 meter only. Half a meter is always left in bearing. It is pierced from end to end for the passage of the liquid used in the press.

The total weight is 150 tonnes (147·63 tons). The diameter of the plunger being 45 centimeters (17·72 in.), a pressure of 100 atmospheres (0·66 ton) will support the whole structure.

The original element in the new design which enables so large a mass to disappear quickly consists in the counterweight of an accumulator, of which the cylinder is in communication with the turret pivot press. The plunger of the accumulator is double the size of that of the pivot, consequently 7·5 tonnes (7·38 tons) is sufficient for the counterweight.

To destroy the equilibrium, water is admitted in the annular cavity round the piston. The differential effect thus produced provides for the vertical movement of the turret, which can be effected as quickly as the rotation, seeing that in each case it is a question only of overcoming inertia. Rotation is effected by means of the horizontal wheel at the base of the turret (see A, Fig. 1), by chain gear, or, better still, by hydraulic gear.

The two subterranean chambers facilitate the working of the gun by keeping the chamber from becoming crowded. The ammunition is brought up to the level of the breech of the gun by a lift from beneath. The carriage is entirely separate from the shield. The port is reduced to minimum size by a jointed frame forming the system of parallel bars shown in Fig. 2. The gun and moving parts of the carriage are supported on an oscillating hydraulic press (see Fig. 2). The recoil is met at the trunnions (as in some of Rendel's designs), so that there is no disturbing couple generated by the shock of discharge.

The muzzle of the gun projects so little that disappearance is not interfered with, and can be effected in all positions. When elevated for a long period, the turret receives additional support brought under the base by hydraulic power, B, Fig. 1. It then rotates on a ring of balls.

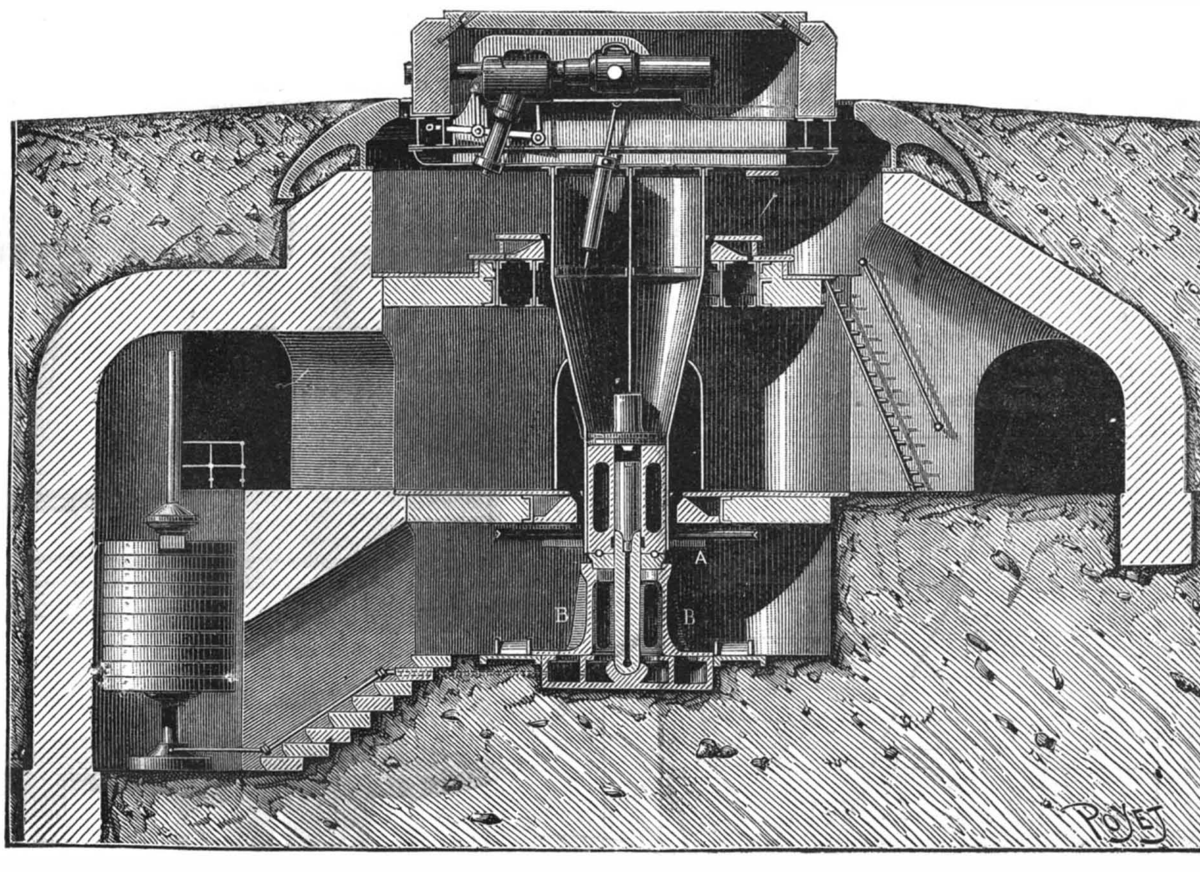


FIG. 1.

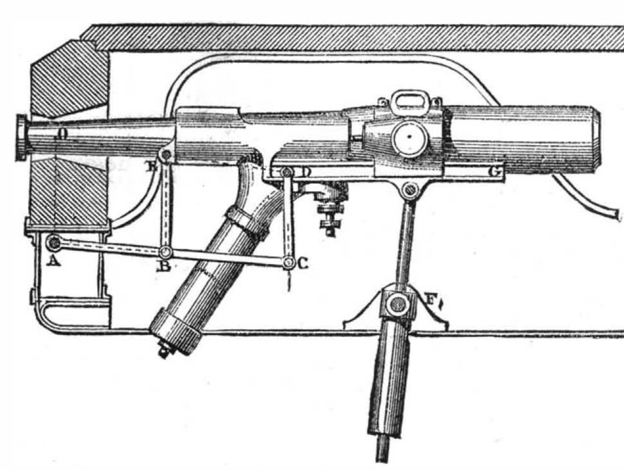


FIG. 2.

THE MOUGIN DISAPPEARING TURRET.

TEMPORARY BRIDGES.

IN the *Russian Engineering Journal* we find a remarkable example of the successful construction of a campaign bridge, despite an almost entire lack of materials. During the campaign of Chiwa, some Russian troops had to cross the Schamrat Canal at Kisil Takir, where the width of the stream at the surface was about seventy-five feet. The inhabitants of the country had constructed a bridge by laying from each side a roadway that ran to the center of the canal, and consisted of earth, sand, reeds, heath, etc. In the middle of the canal there was a break of about fifteen feet in width, that had been rudely bridged over with crooked tree trunks, 16 feet in length and about 4 inches in thickness. Upon these pieces, which scarcely exceeded the opening, had been placed cross pieces, which were themselves covered with sand, heath, etc.

At the moment the troops were about to cross, the bridge broke down under its own weight. It was almost impossible to save any of the wood (which is rare in that country), because nearly all of it was carried off by the current, whose velocity was eight feet per minute.

It was impossible to use trestles, on account of the height of the platform, as well as of the depth of the water and velocity of the current. Moreover, it would have been necessary to set up two trestles, since, with but one, the pieces of wood 8 ft. in length at one's disposal would not have had a bearing of sufficient extent upon the roadways. No reliance could be placed upon the solidity of these latter, and Lieutenant-Colonel Pressowski devised a mode of construction that should better distribute the thrust of the load over the entire mass of the abutments. He decided to construct a bridge such as is shown in Figs. 1 to 5. Three supports in the form of diagonally stayed trusses were constructed of 14 joists, 2 inches in thickness. A beginning was made by marking (Fig. 2) the points, A, C, and B, by means of pickets, upon an even area. After this, the joists, E and F, were placed obliquely with respect to the line, A B, and the joist, D, was placed on top at a distance of 3½ ft. from the line, A B. Then the joists, G and H, which had been prop-

erly trimmed at their upper end, were placed upon E and F, so that after the supports were put in place the joist, D, should rest properly upon G and H. The joists, K, were likewise placed upon G and H, and this system of seven joists was attached by ropes that were wound around as tightly as possible by means of levers, so as to form a rigid whole, in which, at the moment of being put in place, there should be no variation either in the length of the line, A B, nor in the distance of D from A B. The construction of the three supports required the labor of fifteen sappers and five non-commissioned officers. The center support was put in place at 5 o'clock in the afternoon. To this effect, two 20 ft. foot bridges, formed of 8 ft. joists,

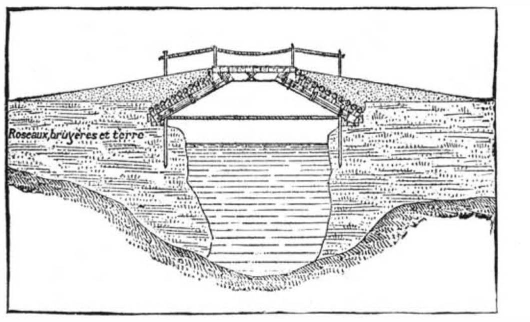
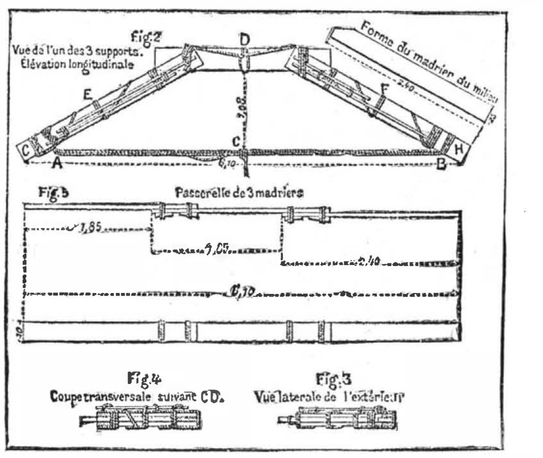


FIG. 1.—PRESSOWSKI'S TEMPORARY BRIDGE.

were constructed over the breach (Fig. 5). The extremities of these were set into the earth to a proper depth, and by means of planks and joists, a good bearing point was formed for the supports. After the placing of the two other supports, three beams were laid upon each of the two arch butments and firmly affixed to them. Between these beams other pieces of wood were placed, then a bed of fagots was laid above, and the joists were well covered with rushes, heath, etc. Finally, the whole was covered with earth, which had to be brought in bags.

The center support was placed horizontally, while the others had a slope of about 1 to 6.

The bridge was finished at 10 o'clock at night, and the troops began to cross at midnight. First, 500 camels crossed, and then the artillery, the convoys, and



FIGS. 2 TO 5.—DETAILS.

the beasts of burden. At 6 o'clock in the morning, all had crossed, and the work of demolition was begun.

Now that we find railroads almost everywhere, it will prove of interest to engineers to learn of another simple and cheap arrangement that permits of the quick replacing of a bridge that may have been carried away by a freshet or some other cause. This arrangement has been devised by Capt. Jose Marva. The type shown in Fig. 6 has a span of 26 feet and a width of 6½ feet. It consists of two trusses, each formed of two 20 foot Vignole rails, A and B, which support the platform, through the intermedium of small telegraph wire cables. At the upper part, the rails enter notches in the piece of wood, K, and rest upon fish plates, so that the wood may not be rent. Their heads are connected with each other and the piece, K, by bolted fish plates, A.

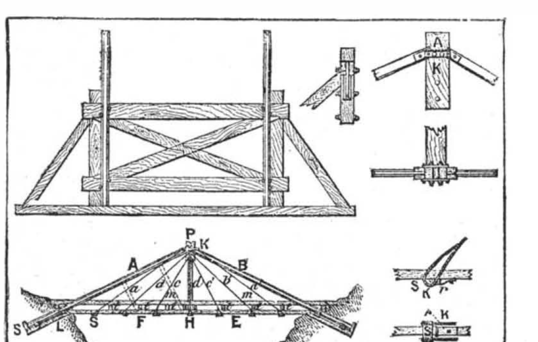


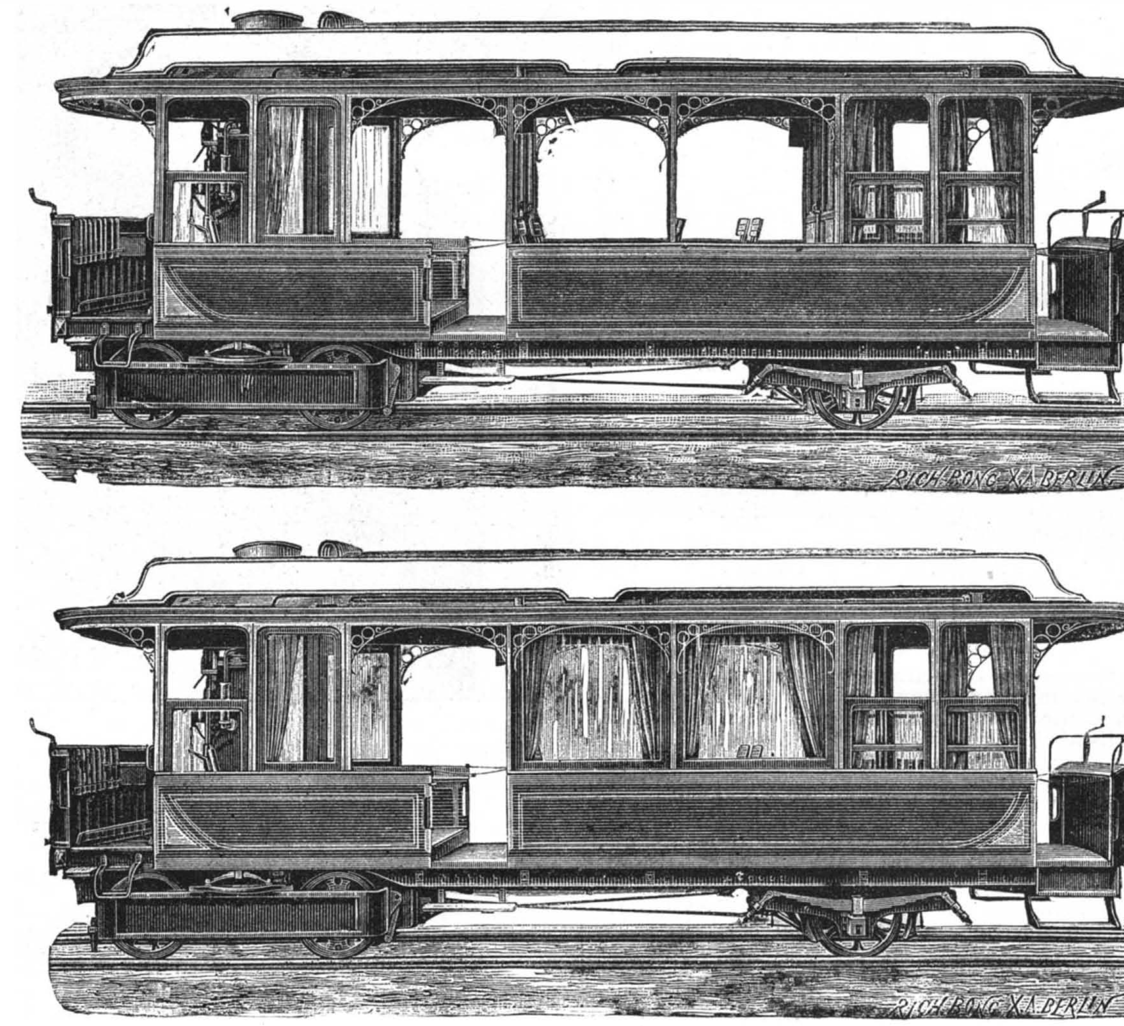
FIG. 6.—MARVA'S TEMPORARY BRIDGE.

The piece, K, is provided with four small rollers of hard wood, two on each face, whose axles consist of bolts. These rollers support the suspension cables.

The trusses are rendered stable as follows: In the first place, two common ties, R, are laid at right angles with the stream, and upon these are placed two others, M and N, which are kept parallel by diagonal braces. The rails are fixed to these ties by the usual method, and their lower extremities abut against the piece, S. Finally, the pieces, T, contribute toward making the entire affair rigid. The longitudinals, E F, are formed of a sleeper sawed in two lengthwise, and the two parts are bolted together in the same manner as the rails are. The cables, *a*, *b*, *c*, *d*, *c'*, *b'*, *a'*, are double (one at each side of each rail). The cables, *a b*, *a' b'*, are formed of three twisted wires, while *c*, *c'*, and *d* are composed of but two. These cables embrace the ends of S, upon which the longitudinals rest. A very important thing to be looked after is the equality of tension in the cables. Mr. Marva obtains this by nailing pieces of hard wood, *r*, under the longitudinals, and then introducing between these pieces and the ends, *s*, wedges, K, which can slide under the longitudinal. By this means a slight deflection may be communicated to the platform of the bridge. The longitudinals support the beams, T, and the platform.—*La Nature.*

IMPROVED STEAM STREET CAR.

THE design of Mr. W. R. Rowan, C.E., of Berlin, was awarded the gold medal at the Antwerp competition of mechanical tramway motors in 1885. Since then these cars have been working very successfully in Berlin, where, however, the grades are not severe, 1 in 40 being the steepest. Several tramway companies in large Continental towns have now had steam cars built under the supervision of Mr. Rowan for their lines with steep grades—Vienna, Stockholm, Pesth, and Naples—and we give below, from *The Engineer*, two illustrations of one of these cars which has been successfully tested on grades of 1 in 13. The first illustration shows the steam car as an open summer car, the second with the middle compartment closed for winter service. The alteration of the car from summer to winter car can be effected in ten minutes. In winter the closed compartment is heated with hot water from the surface condenser on the roof. The following are the principal details: Length over platforms, 29 ft. 4 in.; extreme outside width, 7 ft. 3 in.; weight in working order, 9 tons; wheel pressure on rail with full load, 2 tons 2 cwt.; weight available for adhesion with full loads, 8 tons; number of passengers seated, 36; number of passengers standing, 14; total, 50; traction power of engine, $\frac{6\frac{3}{4}^2 \times 14 \times 180}{24} \times 0{\cdot}6 = 2{,}800$ lb.; horse power, 40 lb.; speed up to fourteen miles per hour; fuel consumption coke, 4½ lb. to 5½ lb. per mile run; surface of air condenser, 1,150 square feet. The steam car is constructed for curves 45 ft. radius, and for grades of up to 1 in 15. It requires fresh water only two or three times during the day, and need only be fired once for every five miles run. No stoker is ever required. Only one man is necessary on the engine. Although not shown, of course, one or more tram-cars may be attached to the steam car, according to the work to be done and the grades.



IMPROVED STEAM STREET CAR.

STEEL SAILING BOAT FOR MR. STANLEY.

MESSRS. FORRESTT & SON, London, have just completed in thirteen working days, for the use of Mr. H. M. Stanley's African party, a steel whale boat 28 ft. long, of 6 ft. beam and 2 ft. 6 in. deep. It is built throughout of Siemens-Martins steel, galvanized, and divided into twelve sections, each weighing about 75 lb. The fore and aft sections are water-tight, giving a large amount of buoyancy to the boat. The sections are bolted together, India rubber being used between the joints to make them water-tight. The boat pulls ten oars, and is fitted with a large lug sail. She will carry twenty-two men and 1,000 lb. of baggage on 17 in. draught of water. The thwarts are of mahogany, and all the fittings are made movable. Each of the sections may be carried easily by two men. The boat was tried on the Thames, both sailing and rowing, and proved to be perfectly water-tight at the joints of the sections. The little vessel can be put together in 35 min., and taken to pieces for transport in 22 min. The boat was shipped on the Navarino of the British India Fleet, belonging to Messrs. Gray, Dawes & Co., who are forwarding all Mr. Stanley's equipment to Zanzibar.

FUEL AND SMOKE.*

By Prof. OLIVER LODGE.

LECTURE I.

I MAKE no apology for bringing before a Royal Institution audience a subject having more connection with the improvement of the conditions of daily life than with abstract science. As a rule, it is no doubt best for a devotee of pure science to adhere to his chosen pursuit, and to speak of that which he best knows; but two things determined me to abandon this course when honored with a request from your secretary to lecture in this place. First, the strong desire which has long possessed me to do something toward helping forward the movement against the physical evils, the paltry and unnecessary evils, under which we dwellers in cities too patiently suffer; and secondly, the remembrance of the spirit and object with which this august institution was founded, and especially of the labors of Count Rumford in the precise direction toward which my own thoughts had been for some time tending.

The pollution of the atmosphere existing in Count Rumford's day, though it very properly excited his disgust and apprehension for the future, must indeed have been trivial to what it is now. Had he been effectively listened to, much of the present evil would not exist; but he was not, and the result is that the vast majority of dwellers in a city—those unable to leave their vocations and retire in the summer to the country—scarcely ever breathe the pure air of heaven or behold the unveiled face of the sun. They eke out their pallid existence in slums and courts into which the sun scarcely ever penetrates and no fresh breath ever blows. There among sweltering filth they live—they die; and so long as they remain sufficiently quiet and uncomplaining, we are content to have it so.

But perhaps we are not content; perhaps we only acquiesce because we do not clearly see a remedy. It is in the hope, rather than in the belief, that this attitude of mind is largely prevalent that I have determined to urge the consideration of the subject in every way that I can and upon every convenient opportunity. Not indeed that I am able to point out a thorough, complete, and instantaneous remedy, immediately practicable; but I do feel able to indicate the main lines on which gradual, I hope rapid, improvement is possible. And that is what I shall try to do.

First, I wish to direct your attention to what is usually called the "combustion" of coal. There are certain bodies which when you heat them *melt* before they begin to do anything else; such bodies are ice, butter, lead, and iron. There are certain bodies which take fire and *burn* when you heat them, before they do anything else; such bodies are hydrogen, phosphorus, and gunpowder. There are certain bodies which chemically *decompose* when heated, before they are able to do anything else; such bodies are marble, feathers, wood, and coal. Bodies in this last category cannot properly be said themselves to burn. Their

* Two lectures in the Royal Institution, London, by Prof. Oliver Lodge, April 10 and 17, 1886.

products of decomposition may or may not be combustible, and, if combustible, they may or may not burn.

The products of decomposition of marble are two—one solid, one gaseous (quicklime and carbonic acid)—and both are absolutely incombustible. The products of decomposition of coal, though far more complex, are likewise roughly separable into two classes, the solid and the gaseous; and both are thoroughly combustible under favorable conditions, neglecting the ash for the present.

It is easy to distill coal, however, without allowing either its solid or its gaseous constituent to burn; it is done every day with full knowledge and design at a gas works. It is likewise done every day, not in knowledge, but in ghastly ignorance, on our so-called coal fires.

Consider for a few minutes the structure of a coal fire; you will see that it has three main stages—still, gas fire, coke fire. You empty on a shovelful of coal. Very good; this has first to be heated and decomposed, separated into its gaseous and solid constituents in fact, and the gaseous ones distilled off.

While they are being distilled they *may* catch fire and burn; but they commonly do not take fire for some time, because they are scarcely hot enough to begin with. And even if hot enough, they are so mixed with carbonic acid from the smouldering mass below that they cannot properly burn. Where is then your fire? It is not a fire at all; it is a still; a sort of crude gas works. It warms nobody. So far from that, evaporation consumes a good deal of heat, and the fire itself below is like to be put out unless it is pretty vigorous.

The coal gas is just evaporating or distilling up the chimney; you can sometimes start it burning by simply applying a match to the ascending stream of gas, but more frequently the carbonic acid soon quenches an incipient flicker, and the poker has to be brought into requisition to increase the supply of air.

(The effect of feeding a flame with carbonic acid was illustrated by lighting a spill at the chimney of a paraffine lamp; also by supplying an ordinary gas jet with burnt air by holding it over a tin plate chimney with a large "solid flame" burner below it.

The flickering, smoky appearance of ordinary fire flames is at once precisely imitated, and the cause of their flickering is perceived. It is easy to put a fire nearly out by burning newspaper under its bottom bars; whereas burning a bit of paper on the top of a dull fire helps it, sometimes to a surprising degree.)

But is it pure gas which is thus ascending? Good heavens! look at it; smell it. You have not far to go. The only difficulty in smelling it is that we get so accustomed to it; our lungs are full of it every winter day of our lives. I believe that if you could suddenly transport a Highlander off his native heath into such a city as, say, Manchester, on a dull day, without the gradual initiation of the train or the suburbs, he would feel nearly suffocated.

How often can one open one's mouth and lungs, and inhale invigorating breezes, in a city? We can sometimes almost do so with a strong west wind; but, ordinarily, people parade the streets with their mouth grimly shut, filtering the air steadily through their nostrils.

The products of a gas works are not gas and coke alone; they include ammonium salts in large quantities, sulphur also, and tar, in which are latent a multitude of useful aniline dyes and other coal tar products—creosote, napthalene, and asphalt. The number of compounds now obtainable from coal tar is quite astonishing; not only color materials, but some medicines also, and quite recently Dr. Fahlberg has extracted a substance with the pleasing name "benzyl-sulphonic-imide," which is able powerfully to excite the nerves of taste in much the same manner as sugar, but some 200 times more powerfully. This substance, about which Sir Henry Roscoe will doubtless next week tell you much more, it is proposed to call "saccharine;" and Sir Lyon Playfair hopes it may replace sugar in the diet of gouty old gentlemen and diabetic patients.

I hope that it may thus subserve beneficent ends; but, with the inscrutable customs of trade at present in vogue, it seems just as likely to lend itself to purposes of adulteration, and to confer sweetness upon sand or some other cheap, and let us hope innocuous, material. (Some specimens of coal tar products were here exhibited.)

The stuff we distill from our incipient fire contains portions of all these; it contains the potentialities of great industries and of fertilizing manures—the gas works is now the main source of ammonia required by plants—and what becomes of it all? Some little is happily deposited in the chimney; the rest hovers about in the air—a veritable plague cloud, the sign of the neighborhood of a multitude of civilized men.

Walking in some unknown part of the country in the autumn, gathering, it may be, the blackberries as you go, you find them getting thinner and thinner on the bushes, and you know you must be approaching a village whose children have been happy here before you. Traveling in some countries abroad, a deep-toned bell or a glistening spire announces the proximity of a town.

In England, its neighborhood is otherwise heralded to you. You have been riding in a train, perhaps, through bright sunshine, when you gradually recognize that the sky looks more gloomy than it did, that the grass does not so happily flourish, that the trees look stunted and miserable; you conjecture you must be near a town. Yes, the gloom deepens, the air feels chill; you can no longer see the sun. It must be a city!

You are soon landed in the heart of it, and you realize that the gloom which perpetually enshrouds the place is the cloud of incense which the inhabitants have raised, either to beautify their common home or as the symbol of the worship of their common god.

The smoke from factories, indeed, is more appalling than the smoke from houses, but I must confine myself to house smoke this evening, though it is essentially all one; and what I say of house fires applies in great part to factory fires, and *vice versa.*

Think now what becomes of the smoke. Its larger particles settle gradually as smuts, some fine specimens reaching ½ in. in length, but the majority are small blacks which crowd the air, which dirty our books, our clothes, and our furniture, and keep one or two maids in each moderate sized house busy in moving it about from place to place. I suppose an energetic housemaid would be happy if she could manage to prevent dust from ever settling—could keep it permanently suspended in the air.

Plenty is in the air as it is—we cannot move in a room without knocking out clouds of it, which are visible enough in a bright light, and which when so seen excite inevitable disgust. But not seeing, we breathe this filth and call it air; our lungs are marvelously constructed, or they would be absolutely clogged, matted together with the reeking abomination we pass through them. We live, but that we live thus healthily and pleasantly is not true.

Plants experience the evil no more than we do, but they have less rapid power of adapting themselves to outward circumstances. They must have clean and open pored leaves—lungs, that is—or they flag and fade. They must have sunlight, or they die.

It is only 200 odd years since apple trees grew and bore fruit in the Barbican. How far are we from such a state of things now? Yet there is no necessity against it. The neighborhood of human beings is rather beneficial to vegetation than otherwise; that which slays them is the tarry and sulphurous compounds in the smoke.

The tarry products of coal smoke are abundantly evident in the atmosphere; our buildings, our statues, our hands, are coated over with a black grease, and washing four or five times a day scarcely keeps them pleasantly clean. And then the sulphur! Sulphur burns to SO_2, and this soon oxidizes and dissolves to sulphuric acid—oil of vitriol. I do not care much for statistics, but it is easy to reckon how many hundred tons of sulphuric acid are turned loose into the London air per day. You have only to find out how much coal is burnt in a day, and then the average percentage of sulphur in coal—2 per cent.—will give you the result; 6 tons of sulphuric acid are produced per 100 tons of coal burnt.

Think you that oil of vitriol is wholesome breathing for plants and animals? It must corrode and gradually undermine the strongest constitution. It attacks books, pictures, buildings, most visibly; it is dissolving the present Houses of Parliament—perhaps the one good thing it is capable of.

Well, so much for the first stage of our coal fire, when it is really a still or gas factory. Now for the second or flaming stage. The gas coming off now is of a more easily combustible nature, and being also of a higher temperature it burns, and so far as it completely burns, it constitutes a gas fire. Now, many people abuse a professed gas fire, thinking it gives a dry, unpleasant kind of heat and evil smell.

I admit that it is possible for a gas fire or any other fire to smell if it be ill lighted or ill constructed, or if it burns badly, but I deny that a professed gas fire smells any worse than a gas fire which pretends to be something else. If your gas fire smells, something or somebody has to be abused—of that there is no doubt. Sometimes it is the person that lights it. Before lighting any fire, a match should be held in the chimney opening to see that the draught is up the chimney and not down. If you light the fire with a down draught in the chimney, no gas fire can help smelling, and no coal fire can help "smoking." No fire ought to be expected to start its own chimney draught. An up draught must either exist beforehand or it must be made.

If the chimney is in regular use, and if it be built with thick enough walls, its bricks usually keep warm enough to maintain a steady up draught through the night, especially as the night chilling of the outer air helps to maintain the necessary difference of temperature; but if the room be only occasionally used, as is often the case with a gas fire, and other stoves in the house are at work, you will generally find a stream of air being sucked down the chimney—an air supply, in fact, for the house. The room is thus ventilated—especially if it is an upper room with a short chimney—much as if its window was open. It is for a bedroom unconscionably cold, and its air has a sooty flavor.

We are desperately careless how we get air for our houses. We admit *light* with some care and lavishness, if indeed we have any voice in the matter, as commonly in this "dishonored nation" we have not; but we let the *air* leak in as best it can, down chimneys, through coal cellar grids, up drain pipes, and—till quite lately—often through sewers. The cut off system of drainage prevents this last now, and sink traps are intended to prevent scullery pipes from officiating as air shafts. But even without them, if you examine how air is admitted to your house, you will not be pleased.

Through the coal cellar grid, near the ash pit, you will probably find it in a plentiful and constant stream. You may also find it coming in through grids intended to ventilate the spaces between the floors when the bell hanger disports himself. You seldom find a professed and satisfactory air shaft, arranged so as to supply the whole house with deliberately chosen air. Most convenient is such a shaft to warm in winter and to cool in summer.

What we want about a house, and everywhere else, is for each thing to have a definite function and to preserve it. You want a coal cellar to be a coal cellar, and a drain to be a drain, and not to act as amateur air shafts as well.

You do not particularly relish your bedroom being ventilated through a chimney; though indeed, you might do worse than that. You want a window to admit light, and not draughts as well; and doors to admit people, and not bronchitis. Similarly, I prefer a gas fire that professes to be a gas fire, and not one that shams that it is something else.

Well, then, before you light any fire you should turn the draught in the chimney, if it be wrong way, by burning a bit of newspaper in it; quite a small bit usually suffices. There is no possible fear of setting the chimney on fire if you use a real gas fire, because there is no soot. But suppose you have lighted the fire properly and it even then smells, the next thing to consider is whether there is a sufficient air supply to the room, because if the room is nearly air tight a gas fire will smell and a coal fire will technically "smoke."

Into most rooms the air leaks through chinks, through the keyhole, and under the door, keeping one's feet delightfully cool; nevertheless, it is better so than to have no air at all, though a branch from a main air shaft would be best. Supposing, however, that the air supply is sufficient, and the gas fire still smells, then abuse the fire; but do not abuse gas fires as a class, abuse that particular specimen, or at most that and its congeners, and hunt about for some better kind.

The old arrangement of clinkers and fire clay held together by asbestos packed into an ordinary grate is, I suppose, still the most prevalent form. It is not a good form, it consumes a lot of gas in proportion to the heat, it takes some time to heat up, and it is apt to smell. It is extravagant because of the solid or deep arrangement of it. An open fire can only warm a room by radiation, and to this end all hot surfaces should have an unobstructed view of the room. Combustible hot clinkers at the back do indeed help to maintain a fire, but they cannot emit heat directly.

In the case of a gas fire, the clinkers are not combustible, the amount of burning material is strictly regulated by the gas tap, and all hot surfaces behind others are useless, except to warm the chimney. By arranging clinkers as a wall, by playing the flame up their face, and by stopping as far as possible all unnecessary air draught, these asbestos fire clay fires can be improved. Or you may have a vertical slab of fire clay, with filaments of asbestos protruding from it into a flame sheet, whose function is to heat them white hot instantly, so as to give a good radiating surface. I do not suppose that gas fires are yet perfect, but the best kind I know at present in the market are those made by Mr. Fletcher, of Warrington, on these principles.

Here are specimens. The test whether anything comes out of a fire into the room is to burn a bird tail feather in the fire and see if you can smell it in the room. Some of Mr. Fletcher's fires will stand this test.

People further complain of the "dry heat" of a gas fire. I do not know what they mean. A stove, or anything which heats the air, dries it undoubtedly, but a gas fire working by radiant heat can dry the air no more than a coal fire does. It may be convenient here that I explain the main differences between heating by convection and heating by radiation. Any convection method, stoves, hot water pipes, hot air, etc., proceeds upon the plan of warming objects in a room by means of the air. The air is first warmed, and it warms them. Accordingly, on this system, walls and furniture are always liable to be cooler than the air in contact with them.

Now there are certain objections to this state of things. If the air be damp, dew is apt to be deposited on comparatively cold surfaces and to trickle down detrimentally. Not only so, but as Mr. Clark and I have recently discovered, simultaneously with Mr. Aitken of Edinburgh, dust is bombarded out of warm air on to cooler surfaces in contact with it. It is for this reason that ceilings get black over gas lamps, that walls get dirty above hot water pipes, that soot is deposited in chimneys, and lamp black on porcelain. If a flame smokes, extra solid matter is provided by it; but there is usually plenty in town air to make a black patch on a ceiling above a clear flame, or even above an incandescent electric lamp fixed near enough to it. All suspended solid matter is driven out of air on to cold surfaces.

On the other hand, surfaces warmer than the air drive the dust away and keep themselves almost free. A large flat horizontal surface may indeed receive a deposit of dust, even though slightly warm, but it protects itself a good deal, especially from the smaller particles. A vertical or inclined surface may protect itself almost completely. (A new experiment was here shown, of two black conical flasks, one full of hot water, the other of cold, both covered by a bell jar full of thick white smoke. After some ten minutes the cold one was found thickly covered, as with hoar frost, while the hot one remained black.) A radiation system of heating, *i. e.*, open fire or sun light, brings about the opposite conditions.

The air is warmed only by means of solid objects. They are first warmed, and communicate heat to the air which passes over them. Accordingly, on this system, no such effects as we have just described are produced, and things get much less dusty. The only objection to this system is that to do the whole of one's heating in cold weather by pure radiation is unnecessarily extravagant, and leads to a closing of apertures and deficient ventilation for fear of draughts, because, the warming of the air being a slow and indirect process, when once hot it is desired to keep it and not let in fresh.

This is decidedly objectionable, and the best plan of warming a house is no doubt a combination method, both radiation and convection. The air supply should be ample, but it should have the chill taken off as it is introduced. The walls and floor should be heated by radiation, so as always to maintain them a degree or two above that of the air. By properly adjusted arrangements of this sort an exceedingly pleasant and uniform temperature can be attained; and the result is both healthy and economical.

Some stoves intended to aid in the accomplishment of this method I shall shortly direct your attention to. I have not spoken of the cheap and nasty gas fire without flue—no escape for products of combustion. I would not bring such abominations near the place.

A coal fire in the flaming stage is thus essentially a gas fire, but it is a very bad gas fire. The gas is, so to speak, made on the premises and made badly. It is absolutely unpurified, of course, and it is so mixed with carbonic acid that it only burns in a flickering, undecided, smoky way.

Flames interesting to watch! Yes, in a camp fire in the backwoods, or in a fine old isolated country house, they are very harmonious and picturesque.

But in a town! Well, if people are so enamored of the appearance of coal fire flames that they are content to defile and render invisible everything else, all we can do is to stop them by law from polluting the common air for their own amusement, just as one can already stop in some measure the pollution of rivers.

I shall suppose it admitted that the home manufacture of gas is not everything that can be wished, and that it is better, on the whole, to have gas made properly at some central station, purified of its valuable but deleterious products, conveyed to the house silently and cleanly in pipes, and then burnt completely and smokelessly under perfect control; the fire being able to be lighted, raised, lowered, or extinguished precisely according to need. It is better to have such a fire as this than to have a sort of amateur gas works on every

hearth, the supply for which is carted about the streets, shot down with dust and noise into your cellar, carried thence by female labor to the various rooms. "Do just attend to the fire. It's going out." "The scuttle's empty." "Then ring the bell." What a roundabout way of keeping warm! And when fresh coals are put on, what is the result? Frequently a smoky still for some twenty minutes, over which you may sit shivering, not daring to poke it until a welcome tongue of flame shoots out, and you know that the gas-burning stage has fairly begun.

But there is yet the third stage to be considered, the red-hot or glowing stage, when flames have ceased, and the carbon alone is quietly and smokelessly burning. Yes; this is the best and only perfect stage of a coal fire. But what is it really that is burning? It is not coal at all, it is coke. You have consumed or distilled away into the air the volatile products of the gas-making process, and naturally the coke remains. And if you thus like a coke fire, why not try one, or why not burn anthracite, which is almost a natural coke? There is a great deal to be said in favor of anthracite. They burn it largely in Canada, and their cities are accordingly a pleasant contrast to ours. But they don't know when they are well off, the manufacturing mania has seized them, and by protection they deny themselves comforts in order that they may achieve manufactures. Accordingly, they hanker after bituminous coal, and have erected a few tall chimneys now in Montreal, and when thick smoke successfully rolls out of them they rub their hands, and say, "Ah, ha! We are not yet quite a manufacturing nation, but we are beginning to look like one."

Curious mania, this. Very striking for the social philosopher of the future, this greed of people for markets. It is not that they want the goods themselves. No; they will keep them out of their country by taxation. It is not to supply ragged children with boots and clothing that they labor hard and deny themselves the breath of heaven and the light of day, for then it would be noble self-sacrifice. No; it is to ship to China, Africa, Burma, anywhere. And if a shipload of their sold handiwork were sunk they would not lament, they would rejoice, and say, "Lo, now we can make more." Remarkable human nature!

But undoubtedly anthracite or coke can be much more largely burned than it is. And it is a very fairly smokeless, not quite smokeless, fuel. What are the objections to it? It is difficult to light and to keep burning. You want special grates for it, and so on. Quite true. I admit all this, and I admit that no solid fuel can for an instant compare in comfort and convenience with gaseous fuel. Solid fuel needs carting to the house, carrying about the house, the fire needs attention at intervals, which attention is both noisy and dusty, and there are the ashes to be raked out, carried down, and carted away, and the ash of coke is considerable. And every morning, or indeed, without regular attention oftener, there is the somewhat serious trouble of lighting the fire.

Contrast all this with a gas fire. A housemaid brushes up the ironwork once a week when she cleans the room, and that is all the attention that need or can be given to it. You have an illness in the house. A coal fire has to be banked up so as to go on distilling half the night in a black and sulky condition, unfit even to boil a kettle, and yet, if you poke it, it flames and burns with such vehemence that it soon exhausts itself, and, moreover, makes the room too hot. If you have banked it up very scientifically, it may last in this gloomy state till morning, but, if not, the nurse has to get up, and probably wake the patient with the rattle of fire irons. With a gas fire you light it once for all, and need never look at it again for a month, unless the room gets too warm, when you lower it, or too chilly, when you raise it. If you want hot water or toast, it can be cooked immediately. No noise, no dust, no anxiety, and no attention. It is the perfection of a fire.

I said the red-hot stage of a coal fire was its best and only perfect stage. But how short a time is it allowed, or, indeed, able to last! You know by experience that, as soon as only glowing coke is left, it is time to start the gas manufactory again. The heat required to distill fresh coal checks the ardor of a strong fire, and utterly damps a weak one. It must not go too low. You therefore have some more coal put on, and unless you do it yourself, or unless you are in blissful ignorance as to how it should be done, your nerves will be tormented with the bungling and stupidity exhibited in the process.

The method employed for stoking a fire is not the same in all parts of the kingdom. The orthodox London method is not the same as the Staffordshire method. There are two general cases depending on the state of the red-hot fire. It may have burnt into a red-hot hollow cave with a black top, or it may be more solid and red all through. The method commonly adopted in the former case is to beat down the hollow with a poker, and to put the new coal on the top. In the latter case, it is customary to rake the glowing mass a little forward and to put the fresh coal at the back. In Staffordshire the fire is stacked up in a more impressive manner. The fire being still in a sound and healthy red-hot condition, two scuttles are brought in, one full of lumps, the other of small coal or slack. The fire is drawn forward, a row of lumps is arranged on end all along the front, and then the other scuttle is emptied on the back, filling the grate up to the chimney opening with a nicely sloped pile of small coal, till it can hold no more and begins to dribble into the ashpan. Then with a brush the ashes are whisked about from the front bars a bit, and the whole is complete. In two hours that room is untenantable, except by a Staffordshire man or a salamander.

Now all this is wrong. The proper theoretical place for fresh coal is at the bottom of a fire, not at the top. The heat from above will then gradually distill it upward, and the gas as it is given off, having to pass through a hotter mass above, may be almost completely burned. It is scarcely possible in a domestic grate to stoke it really at the bottom, though, indeed, grates on this plan have been attempted. So a compromise is necessary. The next best place to the bottom is the middle, and next to that is the front. If, therefore, you see your fire with a fine hollow in its heart be thankful, and stop the sacrilegious hand that would beat it down. Feed the fresh coal into this hollow either through the bars, or, what often is more practicable, by gently raising a little the top crust. The coal will then take fire almost at once, and smoke will be reduced to a minimum. There will still be smoke, there must be smoke when crude coal is burnt just as it is dug out of the ground, as a savage might burn it, but it need not be excessive. Next time you feed the fire it will probably be solid, and you must then rake it back as much as you can and put the fresh coal in front. Because, as the draught goes a good deal from front to back, putting it in the front is a fair imitation of putting it at the bottom. And if you want the coal to *burn* and not to *distill* up the chimney, you will never put a great quantity on at once. "Little and often" is the motto for all good stoking.

But this is troublesome. Yes, indeed, and I don't care how troublesome it is. The more bother the better. It is our one hope of curing the smoke evil as caused by domestic fires. You attack a manufacturer by means of his cash-box, sometimes his only vulnerable spot. You bully a householder by causing him trouble. When people get tormented about smoky chimneys, they must do one of two things: they must either take the trouble to stoke properly, and so make a little smoke, or they must have some form of gas or coke fire, and so make none. I need not say which course of the two would be the better for the community.

But there is yet one objection. Gas fires are expensive. Well, at present they are. Yes; it will never do to attempt them. Far better live in dim and smoke-laden air half our lives, getting away when we can for a whiff of something fresh and a glimpse of something green, far better to choke each other with the products of our hearth fires than have our gas bills doubled.

No; you say rightly, that's not fair. We cannot legislate for the rich alone. What are the poor to do if smoke is forbidden? Well, to this I may reply first that the very poor cannot, I fear, afford to make very much smoke even now. They have very little fire. Secondly, that the fire of the working classes is mainly a cooking fire, and that cooking by gas is even to-day actually and considerably cheaper than cooking by coal, besides being so much more cleanly. I would also say that for really cheap warmth an open fire is quite unsuitable. A stove is the cheap thing, and it may quite well be smokeless. An open fire is a luxury, by reason of its radiant heat and its ventilation. It is not, and never can be, cheap.

Do I, then, mean that the working classes are to be debarred from such a homely luxury as this? God forbid. They have few enough luxuries at present. I would far rather add to them rather than diminish them. But I cannot compare such a paltry difference as that between one form of fire and another and the far higher and more ennobling luxury of being again able to breathe fresh air, to see a distant view, to feel the brightness of the sun, not once or twice a year on a laborious holiday, but at their very doors, and every day of their lives.

What, then, are we to seek for? We must have cheaper gas. The gas we now burn for illuminating purposes is far too expensive for universal warming, but cheaper substitutes are continually being invented. I hope next time to speak of the Dowson gas, the water gas, the Siemens gas producer, and others. Do not, however, think that gas at 3s. 6d. or 2s. 10d., or even 1s. 6d., a thousand feet is the ultimate thing that science can offer for domestic combustion. It is perceived now that the desideratum is cheap gas, and hundreds of inventors are turning their energies in this direction. Besides, regular coal gas can be vastly cheaper than it is now. The gas itself may be regarded as really a by-product. It is the main pipes and purifiers that are costly, and most of the twenty-four hours these are, at present, almost idle. When gas comes to be used all day long for warming and cooking, instead of only a few hours in the evening for lighting, the same mains will serve for a much greater quantity of gas, and one may hope that its price can then be profitably reduced. Before next century begins, I for one hope to see gas displaced altogether from its domestic lighting function, which it ill and unwholesomely performs, but employed tenfold more plentifully and a millionfold more beneficently in replacing the barbarous, wasteful, dirty, and then, I hope, illegal, semi-combustion of solid fuel.

It is not the products of combustion that we complain about. That which streams from our chimney is no product of combustion. It is a product of incombustion.

Factories are savage sinners in this respect, and them also I must tackle. But now I want to call your attention to some fireplaces which have been devised to mitigate or abate the smoke nuisance. I hope no one will be satisfied with smoke abatement. What I hope to see is smoke abolition. But meantime the contrivances for mitigating the evil are worth attention, and will serve to illustrate the principles I am trying to enforce. Understand that I bring these forward as illustrating one or other important points, not as being any one of them a perfect and heaven-sent contrivance. If one knew of such a piece of perfection, one's task of urging reform would be easy. But that is not the way things generally happen. Progress is commonly gradual, and we must try to go *via* less smoke to none at all.

(*To be continued.*)

ALUMINUM.

THERE is probably no problem which, while certainly capable of—or more properly perhaps adapted for—solution, has so long remained the El Dorado of chemists and metallurgists as that of the introduction of metallic aluminum as an article for every day use. While it remains at between 40s. and 50s. per pound, this consummation does not seem near, and it is not easy to know even now whether to regard pure aluminum as a precious metal or a curiosity of manufacture; probably, in view of the quantity of jewelry and *objets d'art* which have been made with it, the former classification is the more correct, though it is not mentioned in the census relating to precious metals recently published by the Statistical Department of the United States.

The intrinsic value of the pure aluminum made in France, which still remains the chief seat of its manufacture, cannot be regarded as considerable, and it is in the form of its alloys, which possess much value on account of their marked physical properties, that the value and immediate future of aluminum would seem to lie. In a paper read last year by Dr. Sterry Hunt before the American Institute of Mining Engineers, it is stated that remarkable results are obtained by alloying small quantities of aluminum with copper and nickel; one such compound broke at a strain of 49 tons to the square inch, with an elongation of 35 per cent., and a 10 per cent. aluminum bronze broke at 48 tons; such an alloy would be harder than gold alloyed for coinage, and would possess a specific gravity of about 7·8.

Some fifteen years ago, a considerable quantity of pure aluminum was imported from France in the form of jewelry, but whether the quality was inferior, or whether it was too absolute a test of the question whether pure aluminum would withstand oxidation and other chemical influences, it is certain that, although in shops the work looked extremely pretty, it failed to make headway, and distinctly suffered from tarnishing and became brittle. This result was probably due to the action of atmospheric ammonia, as authorities are agreed that the metal withstands the action of acids better than alkalies. The aluminum industry, if the term is allowable, is more indebted to the late Emperor Napoleon than many people are aware; it was he who "retained" that eminent chemist and physicist, Henri St. Clair Deville, for the investigation of the problem of its production, with the result that the process devised by him, now some thirty years ago, remains to this day the principal method of manufacture.

In a shop in the Boulevard Poissoniere, Paris, owned by the Societe de l'Aluminium, may be seen the latest application of the metal. The Societe does not manufacture, but is supplied under exclusive contract by M. Pechiney, of Salindres and as recently as March, 1883, the late Mr. Weldon, F.R.S., spoke of M. Pechiney as the only commercial manufacturer of aluminum in the world. The process in use remains with but slight changes in detail as Deville left it, though such modifications have been introduced as to lower the price, which was quoted at 250*l.* per hundredweight in 1867, to 50*l.* per hundredweight in 1881. The price, however, has more than quadrupled since then if we may accept Mr. Nordenfelt's recent statement that he was not aware that aluminum could be bought at less than 48s. per pound. The most expensive part of the manufacture of the metal is the preparation of the anhydrous chloride and its subsequent reduction by sodium.

Some three years ago there was a flutter in the metallurgical world consequent upon the pretended discovery of a process by which aluminum could be obtained at 100*l.* per ton. On examination of the published details of the process, the fallacy was obvious; the new departure turned out to be in the preparation of the alumina used, and it was subsequently shown that the new method, so far from being less costly, was more costly; the collapse of the process as such was therefore the result. The French method, being of such historic interest, may be described as follows:

Alumina is prepared by furnacing bauxite with carbonate of soda, dissolving out the soluble aluminate of soda, and treating this solution with carbonic acid; on washing the precipitate pure alumina will be obtained. This alumina is dried, heated strongly with carbon, and chlorine passed over the heated mixture; the chloride of aluminum is then decomposed by metallic sodium. We repeat that this process is commercially successful; but when we consider that to reduce 1 lb. of aluminum from its chloride about 3·5 lb. of sodium are required, and that the sodium will cost at least 1s. per pound, we can understand the high cost of the finished metal. Mr. Weldon gave the figures representing the relative cost of the three operations on which the Deville process depends as 9·67, 33·4, and 56·93 per cent. respectively of the total cost, so that the future of aluminum lies either in cheap production of the haloid salts of aluminum and metallic sodium or the discovery of an entirely new process.

Frischmuth's process has for its object the saving of this expensive item of sodium, and consists in producing sodium vapor direct from sodium salts and carbon. Considerable success seems to have attended this modification; and it is now, we believe, being worked at Philadelphia. Mr. Frischmuth made the cap of the Washington monument, weighing 117½ oz.; this cap is spoken of as "huge;" it was to have been burnished, and was stated to be "going to shine like polished silver forever."

It has for many years been regarded as entirely hopeless to attempt the direct reduction of compounds of alumina by carbon, and even Mr. Weldon stated that metallurgists might as well hope to get five from the product of two and two as to attempt it. Since, however, the supposed proof of the absurdity lay in certain physical laws of heat, of combination, etc., and we have no knowledge of how far those laws hold good at elevated temperatures, the objection has not, we think, much weight; and, without being wise after the event, the production of aluminum by the Cowles Electric Smelting Company, in which process, which has been fully described by us, only the direct reduction is mentioned, will seem to controvert the view which so many, in common with Mr. Weldon, held.

It is well known that the temperature of the electric arc is the temperature of dissociation, and therefore alumina cannot exist in it. When to this the presence of carbon is added, we have conditions which upset theoretical considerations, and with suitable apparatus the production of aluminum is an accomplished fact. Seeing, then, that the direct reduction by carbon is effected by simply augmenting the heat, it follows that the production in a furnace, other than an electrical furnace, is within the bounds of possibility. It will be obvious that the reduction will be facilitated in certain cases by using other compounds than the oxide, and many patentees have built their hopes on these compounds. The double sulphide of aluminum and sodium produced by heating together carbon, sulphur, carbonate of soda, and alumina, when highly heated with alumina, is said to set the metal free. Manganese will also reduce aluminum from its sulphide or haloid salt, displacing the sulphur, which goes off as sulphur. This reaction formed one of the last patents which Mr. Weldon took out, and he proposed to produce the sulphide, or haloid salts of aluminum, by the double decomposition of cryolite and the sulphide, chloride, or iodide of either sodium or calcium.

An interesting process, similar to the above, is described in *Dingl. Polyt. Journal*, cclii., pages 515, 519, in which Herr Niewerth mixes ferro-silicon with cryo-

lite in equal proportions and heats to fusion. Volatile silicon fluoride is said to be formed, while the aluminum is left as an alloy with the iron. On fusing this with copper an aluminum bronze is obtained and only a small amount of the aluminum is said to remain with the iron. It is an alloy of the metal and iron, made by the Cowles Electric Smelting Company, which is used in the Mitis casting process. Its average composition is aluminum, 7·5 per cent.; silicon, 1½ per cent.; carbon, about 4 per cent.

Such, then, is the position of the aluminum industry at the present time. We have pointed out that the resistance of the metal to oxidation has not been proved, nor will the mechanical properties as evidenced by the latest researches tend to strengthen the high opinion of its value, which in many cases has, we think, been exaggerated. Thus a wire of No. 18 gauge gave a strain averaging 7·9 tons per square inch. This is extremely low. Cast and hammered aluminum gave 7 tons. By cold hammering 13·2 tons could be obtained. Again, the latest determination of the specific gravity of aluminum is 2·583, which is higher than that generally ascribed to it. The difficulty of working aluminum is very great, and until two or three years ago no means were known for even soldering it, either to itself or other metals. Comparing these results with those obtained from its alloys, it would seem, as we have said, that the future of aluminum lay not so much in the preparation of the pure metal as in the production of its much more controllable alloys, some of which promise to possess a high value as constructive materials.—*Engineering.*

HENDERSON'S STEEL PROCESSES.

WE published a description, on January 15, of Henderson's gas furnace, and we now publish a summary of the results attained by it. It was designed to effect the perfect combustion of fuel, which it does, owing to the means therein described for supplying the gases in the exact chemical proportions in which they are required, and brought together in such a manner that the different molecules may readily do so. As a blast furnace is a perfect gas producer, it used to make the gases (though on a greatly reduced scale). Non-coking coal containing 4½ to 5 per cent. of hydrogen is charged with enough lime to scorify the ash, and it is kept full of coal, and blast at 1½ pounds pressure is forced into the hearth. This regulates the quantity of gas by burning the coke made in the upper part, which contains two retorts, into which the coal is charged. The heat of the producer causes the volatile matter in the coal to distill off, as they contain about eight hours' supply, and the coal is coked by the time it reaches the lower hearth. The flux insures a clean surface on the coke, free of ash. Thus by the gradual distillation of the coal, the clean surface of the coke, and the measured quantity of air, the quantity of gas is accurately known, and also its chemical composition. It then remains to mix them, as they pass through the outlet of the producer leading into the heating chamber, with a measured quantity of heated air applied under pressure in the flues so as to produce thorough admixture and complete combustion. This combustion thoroughly mixes all of the elements in the flame, and it becomes *homogeneous*, and its full chemical effect is exerted upon the articles to be heated from the time it enters until it leaves the apparatus.

Crude iron, mixed with 30 per cent. of steel scrap, exposed in this flame, becomes decarbonized and dephosphorized by the time it melts, if the carbon is about 1½ per cent. and the phosphorus 3½ per cent., and the steel contains 0·04 per cent. of phosphorus. Charging the furnace takes one hour for 12½ tons, melting and pouring two hours, and repairs half an hour. The coal used is about 1,250 pounds per hour. Over one-half of the phosphorus volatilizes, and the remainder is absorbed by the lime worn away from the lining of the hearth. When the iron contains 3 per cent. of carbon less fuel is used, and the operation may be divided by using the iron molten from a blast furnace, by pouring it into the second melting chamber and refining it with iron ore and removing a part of the carbon, which is done by the waste heat of the first chamber. The metal is then run from the second chamber into the first chamber, where it is boiled and decarbonized into soft steel, in one hour, by use of brick of iron ore and fluorspar partially covering the hearth. While a charge is refining in the second hearth, the previous charge is being decarbonized and finished in the first hearth; and allowing half an hour for repairs, the operation occupies one and a half hours for converting crude iron into soft steel, so that sixteen operations may be made in twenty-four hours, or a furnace of 12½ tons capacity be made to produce 200 tons of steel per day, from a plant costing $15,000 exclusive of building, the consumption of coal being 150 pounds, which is but one-fourth of the coal used for the coke to melt a ton of pig iron in cupola. The arrangement for burning the carbon of the iron in the second chamber utilizes half as much fuel as the gas producer supplies. The use of iron ore adds about 5 per cent. of steel above the weight of the pig iron charged, so that the 7 per cent. of impurities in the pig iron is replaced by iron derived from the ore, or 12 per cent. of steel is derived from it, and by skillful manipulation of the furnace but very little oxide of iron remains in the slag. By heating the ingots with radiated heat, there is no waste by oxidation, and they may be rolled direct to the rail without loss, yielding twenty-one cut of rails and scrap from a ton of pig iron.

Phosphoric pig iron gives better results than Bessemer iron, as the flame removes the phosphorus to less than half that usual in Bessemer iron and steel. The phosphorus is almost all recovered as by-products, except that left in the steel. A part combines with the lime worn away from the hearth and becomes phosphate of lime, which is pulverized and used for manure by spreading it over land. The other part is volatilized and cooled and condensed in milk lime to become phosphate of lime when no fluorspar is used; but when fluorspar is used, fluoride of phosphorus is produced, and it is condensed in cold water, and the phosphorus is separated by draining away the hydrofluoric acid, which is made by the decomposition of the gas. Milk lime may be used instead of water, in which case the fluoride of phosphorus combines with the lime, and they become artificial apatite, which is a substitute for phosphate of lime for manure. Crude iron containing 3½ per cent. of phosphorus yields enough by-products to enable the steel ingot to be produced free of cost, as every 1 per cent. yields phosphate of lime worth $4.15 net per ton. These processes also enable the use of crude iron containing sulphur, that would otherwise be unfit.

These inventions produce the perfect combustion and utilization of fuel, and enable the use of all kinds of iron ores and fuels for the production of steel with great economy, and the utilization of the hitherto deleterious elements in crude iron as valuable by-products, and a comparatively valueless reagent—fluorspar—becomes the source of supply of hydrofluoric acid at a merely nominal cost. This acid is a useful reagent in manufacturing, such as separating animal from vegetable fiber, treating alkaline chlorides to form potash and soda, and for producing artificial fluoride of calcium in the steel processes, and other uses.

REASONS WHY MERCURY MAY BE CONSIDERED A COMPOUND OF GOLD AND THALLIUM.

THE specific gravity numbers given are taken from the Encyclopædia Britannica, and the atomic weights from Wurtz's Atomic Theory.

	Specific Gravity.	Atomic Weight.
Gold (ingot)	19·26	196·2
Thallium	11·86	203·6
Mercury	13·26	200·0

If the atomic weights of gold and thallium are added together, and divided by two, we get almost the exact atomic weight of mercury, the figures being 199·9. The fact may be referred to here that the theoretical vapor density of mercury has also to be divided by two to get the value obtained by experiment.

An alloy formed from equal weights of gold and thallium would have a specific gravity rather more than that of liquid mercury; but as there is known to be an expansion of volume with some gold alloys, the discrepancy in this case does not prove anything.

It will be noticed from the figures that there is exactly the same difference between the specific gravities of gold and thallium as there is between their atomic weights—7·4; the metal having the highest atomic weight possessing the lowest density, which would appear to show some connection between the two properties.

A similar relationship may perhaps exist between other pairs of elements, although the figures are not as close as in the case of gold and thallium; silver and palladium, copper and zinc, platinum and iridium, nickel and cobalt, are instances.

Of all the metals that are not rapidly oxidized in air, thallium is the softest, being scratched even by lead, and melting at 190° C. When in a liquid condition, it looks exactly like mercury, and like that metal is not attacked by hydrochloric acid. It is a very widely distributed substance, being found principally in combination with iron and copper sulphides, in pyrite associated with gold and other metals. By means of spectrum analysis, a very minute trace of the metal can be detected, as it gives a characteristic bright green band, which has been noticed in medicinal preparations of mercury which are presumably pure. The band visible in such cases may be due to a slight trace of free thallium, present as an impurity, but it may also possibly result from a slight decomposition of the mercury, and this may also occur in the animal system, which would account for the presence of gold in the body and excretions when, so far as known, it has not been swallowed.

According to medical works, the action of gold on the animal system more nearly resembles that of mercury than any other metal. This was also shown by some remarkable experiments recently tried in France, the mere proximity of some substances producing powerful effects upon certain individuals; the action of gold and mercury, and the chlorides of these metals, being especially strong and precisely similar. As well known, thin films of gold transmit light of a green color, but if largely alloyed with silver, the light is violet. The light passing through thin films of mercury is bluish purple; and as there is not much difference between this and violet, silver and thallium may be supposed to modify the transparency of gold in a similar manner. It is rather significant that, with the possible exception of copper, gold and mercury are, so far as known, the only metals through which light can pass, even the infinitely thin films of silver which can be produced by chemical action being absolutely opaque.

The liquid condition of mercury is a fact in support of the compound theory, because generally a combination of two or more metals is more easily brought to a liquid condition than the components would be separately, a mixture of sodium and potassium being, in fact, fluid at ordinary temperatures. The addition of lead lowers the melting point of platinum more than 1600° C., which would be more than sufficient to liquefy gold, the melting point of which is 1100° C., and is said to be reduced to about 400° by the least trace of silicon, and if heated with a large proportion of zinc, the two vaporize together. Lead also has a remarkable effect upon gold, the 1-2000 part making it extremely brittle, and altering its color. The readiness with which mercury is attacked by substances which have no effect upon gold, nitric acid for example, may be compared to the action of this acid upon platinum alloyed with silver. The great resistance offered by mercury to an electric current, its high specific gravity, its power to dissolve gold, and its greater affinity for that metal than for any other, are facts which also lend support to the theory advanced.

With regard to the differences which exist between the three metals, they are less than those which exist between some known compounds and their constituents —bisulphide of carbon, for instance, a colorless, very volatile liquid formed by the combination of two solids, one yellow, the other black. The properties of compound radicals may also be referred to as meeting a possible objection to the theory.

Assuming that mercury consists of the metals gold and thallium, it is probable that the latter did not exist in the free state until their separation from each other, that they were produced together in the form of mercury, perhaps from non-metallic substances. If this theory is correct, all the gold obtained has resulted from the decomposition of mercury, sometimes on the spot where the gold is found. This appears a reasonable supposition, from the fact that those States from which the most gold has been obtained are the richest in various ores of quicksilver, and as far as this country is concerned, are the only ones where the ores exist in any quantity. A native gold amalgam is found in California and Columbia, having a definite composition, the former variety existing as yellowish white, four sided prisms. A native silver amalgam also exists, and may be explained in the same manner as the presence of silver in gold. There appears to be an immense quantity of gold amalgam in the bed of the Carson River, Nevada, and is brought up by means of steam dredges. Mercury and gold are also present in the Steamboat Springs of the same State. Even in quartz ledges mercury is found, some of the quartz geodes in the Pioneer Mine, Napa Valley, containing several pounds of the metal. At Sulphur Springs, Clear Lake, native sulphur exists in quantity associated with quicksilver ores, and native gold has been found in water-worn masses not far from the same locality. Although there is a strong affinity between gold and metallic mercury, there is none between gold and an ore of that metal, and the fact that they are found in combination is very strong evidence in favor of my view.

It does not seem likely that gold, whether quartz or placer, is derived from a chloride of gold solution. In many, many cases, there is no evidence of chloride having been present, and even so, that theory would not explain the presence of silver in combination with the gold, because that metal would probably have been precipitated as chloride of silver, and the gold itself thrown down in a state of fine division, by the action of iron or other reducing agent; and there is no other known solution of the metal that would satisfactorily explain the conditions under which it is found, especially the formation of crystals and its aggregation sometimes into large masses. In view of known facts, the theory of heat is inadmissible, nor is it probable that all placer gold has been derived from the disintegration of auriferous quartz, not only because of the greater average size of the particles found in alluvial deposits, but also because the latter is purer; at least such is the case in Australia, of the gold fields of which I have had some experience. There, as in this country, well defined crystals are found under such conditions that they must evidently have been formed *in situ.*

Admitting that gold is derived from mercury or some of its compounds, the various conditions under which it is found, as well as the presence of other metals, would be satisfactorily explained. As thallium is obtained from the mother liquor of salt works, the presence of gold in sea water can also be accounted for on this theory.

In order to prove the correctness of the theory, it is not necessary that those countries which contain large deposits of cinnabar should also have abundance of the precious metal. Diamonds are not found wherever deposits of carbon exist. There would have to be favorable conditions and the presence of various other substances, and it is probably not every ore of the metal that would answer for the purpose. I know by experience what important effects are produced in the compounds of mercury by the slightest trace of some other substance; the presence or absence of some slight impurity in the water or chemicals used modifying the expected results in a most perplexing manner. This is especially the case when experimenting with the salts of the metal for electrical purposes, as I have been doing for several years, it being discoveries made in that way that first caused me to consider mercury a compound; and although the reasons given to prove that such is the case, and that it consists of two known metals, may not be as convincing or conclusive as those given by eminent chemists in support of the view that not only mercury, but every other substance, consists of congealed ether, hydrogen, or some element not yet proved to have an existence, still I think the evidence submitted is entitled to consideration, even if it involves the necessity of admitting that those much abused individuals, the alchemists, might after all have been right.

A. C. COUSENS.

THE RELATIONS OF TEMPERATURE TO HEALTH IN DWELLING HOUSES.*

By D. BENJAMIN, M.D., Camden, N. J.

WHAT is generally called a cold is always produced by some change of temperature, with or without moisture, to which a part or the whole of the person has been exposed. In most cases the change must be from a given temperature to a lower one, in order to produce a cold. One is more apt to take cold if a part, and not the entire body, be exposed to a low temperature. Dampness adds greatly to the power of a low temperature to produce a cold.

A cold is a disturbance of the circulation of the blood, whereby a part of the body has too little blood in it, and, therefore, some other part has too much.

The part that has too much is said to be congested, and if the congestion is not promptly relieved by treatment, inflammation is sure to follow. If in the throat, croup; lungs, pneumonia; bladder, cystitis, etc.

The human flesh is elastic and contractile, and, therefore, when cold is applied to a part it contracts, holding much less blood, consequently some other part must contain more than it should. Moreover, all vital action goes on more slowly in a low than in a high temperature, so that by cooling a part overmuch its nerve energy and vital force are greatly affected, causing delayed and dangerous reaction, or actual destruction of a part, while the undue blood in some other part of the body lights up inflammation that would not have been called into existence without this stimulus.

Cold applied to the skin generally produces congestion of the mucous membranes, because of their similarity of construction, nerve supply, and continuity of structure to the skin.

The most healthful temperature for the human body to live in is about 70° Fahr.

In a slowly moving atmosphere at 70° Fahr. a person cannot take cold, but a change of 10° Fahr., especially if it is sudden, is often sufficient to cause one to take cold.

The foregoing are undeniable truths, based on physiology, chemistry, and physics. Their importance and the practical application of them, especially in the pre-

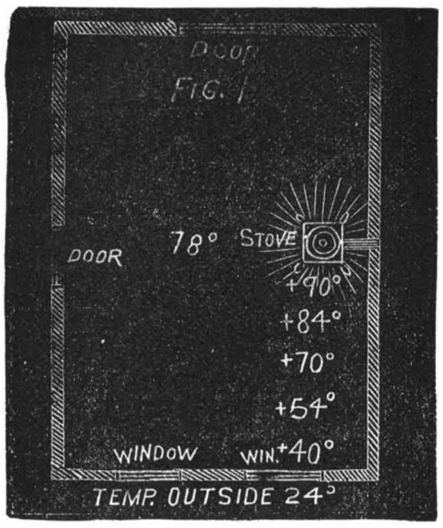
* Revised from "Some Observations on the Relation of Dwelling House Windows and Temperatures to Acute Inflammatory Diseases," in the *Medical Bulletin*, May, 1886.

vention and treatment of diseases of the respiratory organs, we will now consider.

A few years ago I began making some observations and experiments on the circulation and temperature of air in rooms, with results which appear to me to be of practical importance.

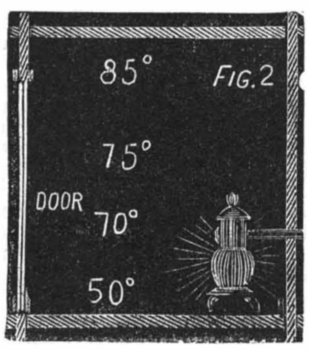
The conditions of temperature and circulation of air vary greatly in rooms, especially those that are in use.

Fig. 1 gives results of experiments in a room ten feet high, twelve feet wide, and twenty feet long, with a



good stove and steady fire. Three-story brick house, south front, twelve rooms, warm cellar. Out-door temperature, 24° Fahr. By examination of Fig. 1, it will be seen that when the center of a room is 78° Fahr., four feet from the window it may be 70° Fahr., one foot from window 54° Fahr., and at window 40° Fahr. (no doors or windows having been opened for thirty minutes), a difference in the room of 38° Fahr.

In Fig. 2, a vertical section of same room, it will be seen that while the head is in 75° Fahr. the feet may be in 50° Fahr. What must be the effect on a person who



removes his warm boots and wears slippers, or the one that lies down to sleep on such a floor? Many do these very things, however.

Fig. 3 shows an every day occurrence among thousands, yes, millions, of people. A child three or four years old, from playing near a stove or on a nurse's lap, in a temperature of 70° or 80° Fahr., perhaps in a sweat, goes to a window and stands, without any change of clothing or protection, for half an hour or

more, in a temperature anywhere from 30° to 55° Fahr. How such a thing can occur without resulting in croup or pneumonia must be marvelous to any one who studies the subject even casually.

In many instances there is a small crack or opening either under the sash or at the side, and almost always at the junction of the upper and lower sash, where a stream of air is passing into the room nearly as cold as the outside air, though it be below zero. Cold air at a high speed striking a child directly on bare throat or breast can seldom fail to produce some dreadful disease.

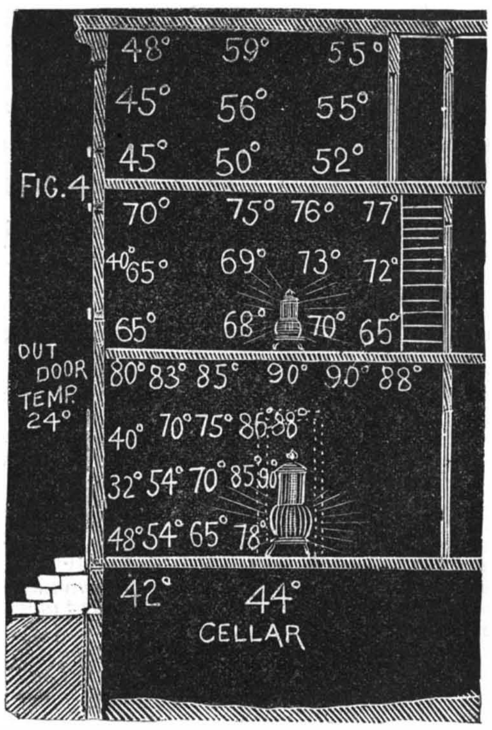
On a very cold day, in some of the wooden houses inhabited by poor people with many children and little time to look after them, children may often be found sitting on the floor in a temperature of 38° Fahr., or standing with nose against window pane at 20° Fahr., when the mother is washing or ironing in 65° Fahr. These people generally have but one fire in the house, and that in a cook stove, which cannot heat the floor at all, while cold draughts come from every other room, and especially from the stairway.

In churches and theaters the galleries will be 85° to 90° when the floor is 70° Fahr. Then the opening of a door or window is very injurious, and going out into the air at 10° or 20° Fahr. also causes a dangerous strain on the system.

In view of the principle already given, it seems to me that this is a striking state of affairs, and perhaps no principles of hygiene are so grossly violated as these. No wonder that the death list in Philadelphia alone in a single year reaches the dreadful sum of one thousand from pneumonia and about four hundred from croup (preventable diseases in most cases). It is also somewhat remarkable that the subject has not before been written up in medical works. The thermometry of hygiene and the sick room is a fruitful field for cultivation.

By reference to cuts, it may be seen that it is easy to be exposed in five seconds to a change of 40° Fahr., a circumstance that can never occur out of doors. In open air the temperature is nearly the same from head to foot, and changes much more slowly than in the house. A child gets off the bed and sits on the floor, a change of 10° Fahr., it may be 20° Fahr., or it goes to the window, possibly to scratch in the beautiful frostwork on the glass, a change sometimes of 40° Fahr. This explains why people take cold more frequently in the house than they do out of doors. In fact, I do not believe that people will take cold by habitually going out if they exercise and are properly clothed.

By reference to Fig. 4, it will be seen that when the first floor was as low as 48° and 50° Fahr., the second floor was 65° Fahr., and all the second floor room was



of a more even temperature. This is owing, of course, to the cold under the first floor and the heat, 90° Fahr., under the second. It shows why the sick should be, if possible, in the second story, over a room that is heated, and why relapses occur when patients are permitted to come down stairs. The contrast is greater in many instances than shown in the figure, which represents a grade of houses better than the medium.

Most of the foregoing experiments may be performed as follows: Take one and a half dozen thermometers (common japanned tin cases), set them in water very cold, 33° Fahr., and well stirred; ascertain the difference in the register, if any, and note it by pasting a little slip of paper with the correction on it near the top. Then place the thermometers all in water at 120° Fahr., well stirred, and correct as before; then in water at 70° Fahr., and correct. These corrections will render them sufficiently accurate for practical purposes. Lay six of them across the floor, or, better, on blocks one-half an inch high, in a row, equally distant one from the other, extending from wall to wall; then stretch a string or wire across the room in the same vertical plane as the row of thermometers, and hang another row on it right above the first; stretch another row across in the same plane at ceiling. You will then have three horizontal rows and six vertical rows. Wait thirty minutes, then read off the temperatures, and record them on a piece of paper to represent the vertical section of the room. Any number of such sections may be made in a room, and should be made to include windows and doors as a main feature. Temperature of windows can very easily be taken by placing or hanging thermometers on the sash.

It is clear from what has been stated that to keep well or to treat diseases, especially of the respiratory organs, such as pneumonia, croup, pleurisy, bronchitis, coryza, etc., we should keep an even temperature of about 70° Fahr. The thermometer should be on a level with the patient's head and near by; a good way is to hang it on the bedpost at the head of the bed, and the mercury should not be allowed to fall below 68° Fahr., or rise above 74° Fahr. If the floor is warm, the whole room can easily be kept so.

A bed should not be against a cold wall. If it cannot be in the middle of the room, it should not be near a window or door, and should always be pulled out from the wall six inches or more, so that the cold air, which always descends along a wall, can have room to drop to the floor without flowing over the bed. A great many cases of rheumatism and neuralgia come from sitting near a window.,

I have often tried lecturing parents and nurses about the importance of keeping children away from windows, but it is very often impossible to have the instructions obeyed. Windows are very attractive to children, especially when the weather is too severe for them to play out. Any woman's mind would be dreadfully strained who has her housekeeping to attend to if she were compelled to keep her eyes constantly on a number of children, even if she could compel them to obey when detected.

Some years ago I devised a contrivance to protect children from the death-dealing windows in cold weather which has given me, as well as parents, much satisfaction. It is simply a fender of metal (also made

of wood) about three feet high, and extending out from the window fifteen or twenty inches.*

In some families where I have had these screens arranged to the windows for one or two years, I have reduced the medical attendance very greatly, as my books will show.

In Canada many of the dwelling houses have double sash, glass about four or five inches apart, a very good device, and one that diminishes the coal bill also. They are a little unhandy to keep clean.

About two thousand cubic feet of fresh air is needed per hour for each individual in a room, and when no fresh-air registers are provided, can only be supplied through the keyholes and cracks around the doors and windows, making necessarily strong and dangerous draughts. The only resource left the physician, therefore, is the making of strenuous efforts to have people keep away from the dangerous places.

Leaving bedroom doors ajar or windows slightly raised in cold weather is sometimes dangerous, on account of draughts, and though it may be occasionally necessary, it generally requires more knowledge of sanitary science than is possessed by the masses.

On being called to see a case, I rarely find a thermometer in the sick room; its importance is not realized by the laity (or the profession). If there is one about, it is out of doors, or often good for nothing. The amount of ignorance in regard to the thermometer is remarkable. I often find people using one that is broken, and working against the pressure of the atmosphere instead of a vacuum. Once a lady said to me on my second visit: "Doctor, I don't see as that theomiter is any good; I've been a-watchin' it, and I had to use more coal to keep the room warm than afore I got it; I gist might as well a-throwed the money away." Still, I am in the habit of ordering a thermometer with the first prescription, though many would apparently pay five dollars for medicine more freely than twenty-five cents for a thermometer that might save ten times that amount.

No one can tell by his own feelings whether a room is warm or cold, for often you will see two persons contending in the same room, one that it is too warm, and the other that it is too cool. It is obvious that we cannot regulate for invalids or others by our feelings. The only unerring guide is the silent, sensitive little column of mercury.

The more rooms that are kept heated in a house, the less draughts will be found. Especially heat the halls; it will not take much more coal, and will avoid forcing your heaters or stoves, and enable you to keep easy fires. Keep the cold air from under the house also.

The artificial life of civilization causes greater susceptibility to colds at the same time that it exposes us to greater changes of temperature; but science enables us, on the other hand, to oppose with some success these pernicious influences. The study of this subject shows not only the varied principles that lie at the foundation of successful practice, but also the importance of the collateral sciences to medical education. And it is believed that even the few suggestions of this paper, if properly applied, would reduce the amount of sickness and death consequent upon the habitual neglect of easy precautions.

THE POISON OF THE STINGING NETTLE.

By ALFRED W. BENNETT, M.A., F.L.S., Lecturer on Botany at St. Thomas' Hospital.

SOME considerable time ago, I called attention to the unsatisfactory state of our knowledge respecting the fluid which gives the pungency to the stings of our common stinging nettles, *Urtica dioica* and *urens*, and pointed out the difficulties in the way of accepting the ordinary theory that it is due to formic acid. Dr. G. Haberlandt, in a paper on the "Anatomy and Physiology of Stinging Hairs," read before the Academy of Sciences at Vienna, has now given the *coup de grace* to this hypothesis, showing that formic acid has no such virulent properties in the minute quantities in which alone it could be present in the stinging glands of the nettle; and that the irritation must be produced by a fixed substance, since the

* At my request Mr. C. F. Hollingshead, of the Cooper's Point Iron Works, has prepared some very convenient and ornamental designs.

dried contents of the gland will cause the ordinary effects of a nettle sting if introduced beneath the skin, while formic acid is, of course, volatile. Dr. Haberlandt finds, on the other hand, invariably in the fluid a substance which possesses all the properties of an albuminoid; it is destroyed by boiling water. The substance which produces the irritation is probably, he considers, of the nature of an unformed ferment.

Dr. Haberlandt's experiments seem to me, valuable as they are, rather to open up more widely than to close this interesting subject, and I commend it to the attention of chemists who have the opportunity of investigating it further.

The mechanical contrivances for the ejection of the poison Dr. Haberlandt found to be similar in our wild stinging nettles and in the tropical species of *Laportea*, *Loasa*, *Blumenbachia*, *Cajophora*, *Jatropha*, and *Wigandia*, in many of which the virulence of the poison is much greater. In all, the sting consists of a multicellular base surmounted by a very large secreting cell. Below the silicified apex of the latter the cell wall is always very thin. While in our stinging nettles the brittleness of the recurved apex of the sting is occasioned by the deposition of silica, in *Loasa papaverifolia* the same effect is produced by calcium carbonate, and in *Jatropha stimulata* by the lignification of the cell wall.

HISTORY OF THE WORLD'S POSTAL SERVICE.

IT is safe to predict that the future historian of civilization will include the 9th of October, 1874, among

FIG. 1.—TEACHER CORRECTING TABLET.

the proudest days of glory, and will cherish it more highly than many other days we are accustomed to celebrate.

It was upon this day that the first agreement was signed at Bern, according to the plan and suggestion of the genial Postmaster-General Dr. Henry Stephan, to which we owe the present complete arrangements of the world's mail or postal union. This Bern compact

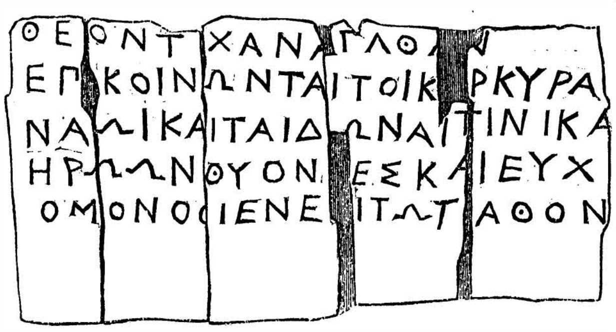


FIG. 2.—ORACULAR PLATES.

stands among the noblest deeds of our time, for it has united the remotest distances, and the world's postal service of to-day spins a gigantic net around the inhabited globe.

As Geneva lent its assistance in agreeing to protect the wounded, so Bern has helped to bring noble thoughts into action by promoting the intercourse of civilized nations. We wish to present to our readers an account of the development of the postal system, as shown in O. Veredarius' book, "The World's Mail," published in elegant style by Hermann J. Meidinger, Berlin. In the perusal of this work, we find the comforting thought that there is at least one sphere in

FIG. 4.—DELIVERY OF AN EGYPTIAN LETTER.

our time in which progress may constantly unfold itself with freedom.

Surely the ancients were not familiar with postal arrangements, and this is easily accounted for by their having but a limited supply of writing materials. Neither wax tablets like that represented in our picture (Fig. 1), taken from a painted vase, showing a scholar in the act of handing his tablet to his teacher for correction, nor the leaden plates (Fig. 2) upon which the pilgrims wrote questions when they consulted the oracle of Dodona, were appropriate materials to send by mail.

The first advance in this respect was the papyrus, which became generally used. But for a long time mankind was very backward in regard to writing, and little inclined to the interchange of thought. Only occasionally do we hear of a letter, for example, in the Jewish realm of the Uriah letter, and in the Grecian heroic age of the letter that Bellerophon carried by order of King Proitus, from Tiryns to Lykien, containing an order to put the bearer to death. Pictures on vases represent such things vividly. The illustration given in Fig. 3 is taken from an old Grecian vase in the museum at Naples, and represents Bellerophon just as he is receiving the fatal missive.

FIG. 3.—BELLEROPHON RECEIVING THE LETTER.

The real origin of letter writing was in Egypt. We give an illustration of an old Egyptian picture taken from the sepulchers of Chuumhotep at Benihassan, about 2,000 years before Christ (Fig. 4). It represents the delivery of a letter announcing the approach of a tribe of Shemitic emigrants, and shows plainly the two forms of letters then in use, namely, an open sheet and a closed roll.

Systematic perfection, however, was not attained by this arrangement, either in Egypt or in Greece. The giant states of antiquity, the Persian and Roman empires, were the first to feel the necessity of a regulated postal and intercourse system.

Herodotus and Zenophon were full of admiration for the postal arrangements in the Persian empire, of which they have left vivid descriptions. Horses stood ready for exchange at fixed intervals of space, and all arrangements were carried out with incredible speed and certainty, at least in the eyes of the Greeks, who were accustomed only to the most primitive methods at home.

Rome probably borrowed the model of its postal system from Persia. The origin of the "Cursus publicus," or public post system, is traced back to Augustus. It became a necessity in order to bring about a system of rapid communication between all parts of the empire and, in its way, was worthy of imitation.

It was a day's journey between each "mansio" or station, where forty mules at all times were kept standing in readiness. The "mutations" which were between the "mansiones" were intended simply for the exchange of horses, and not for shelter to travelers, and here were always twenty animals.

FIG. 5.—THE ROMAN MAIL CARRIERS.

It was the duty of the inhabitants living near these stations to attend to the relay of the horses, and it was exceedingly irksome, for the "Cursus publicus" was used not only for the mails, but also for passenger traffic, and the Roman noblemen frequently took advantage of it to go on cheap pleasure trips.

When the Emperor Nerva tried to remedy this, the mere determination was greeted with such joy that even money was coined to celebrate the event. Little relief, however, was afforded to the provinces during the reign of Nerva and Trajan.

Adrian was the first to bring about an actual improvement. By making extended journeys, he became personally convinced of all the existing inconveniences, and through his efforts the entire system became perfected.

The station houses were made roomy, and were furnished comfortably enough to afford satisfactory shelter even to the noblemen of the empire, and in like manner the transportation service satisfied the most extensive demands. Thus, among other things, legionary families were carried back and forth during the delays of disputed claims; and even wild animals for the circus were transported by this means.

The illustration that we give (Fig. 5) includes a view

FIG. 6.—MONASTIC POSTAL SERVICE.

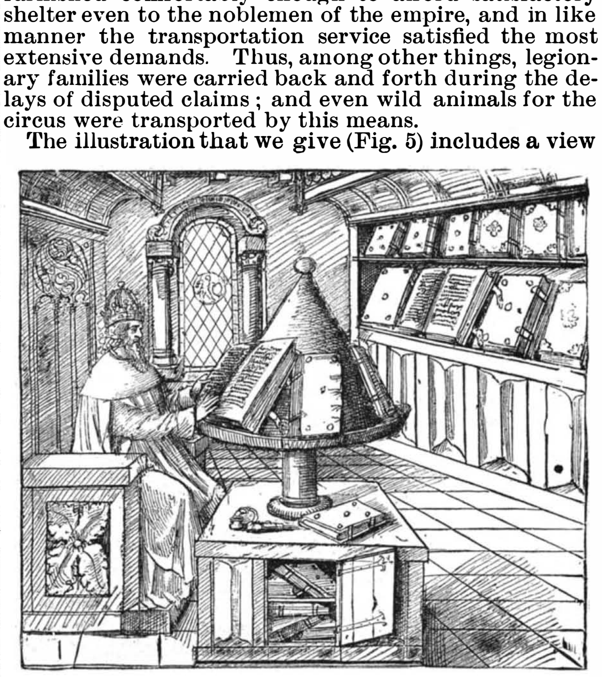


FIG. 7.—THE KING'S WRITING CABINET, FIFTEENTH CENTURY.

of the "Cursus publicus," as drawn by L. Burger, and, like all the other illustrations accompanying this article, is taken from the above mentioned book by Veredarius. This postal system was destroyed with the Roman empire, during the tumult of the migration of races. The stations were destroyed, around which settlements, and even cities, had partially sprung up.

It was a time of continued conflict, of universal mistrust. It was the beginning of the middle ages, when postal communication was not needed. Only the monasteries preserved the miserable remains of civilization. They were the first to make renewed endeavors, as their aim was to bring about a closer communication between allied institutions. Cloister messengers ran through the country, and by them a more intimate intercourse was effected between all monasteries founded by the Abbot Clugny and the original institution. These messengers went also over the Alps toward Rome, and the first postal station for this purpose, in the middle ages, of which we have knowledge, was founded by the Millstatt Monastery in Karnten, which was at that time wealthy and renowned.

Fig. 8.—JAPANESE POSTMEN OF THE MIDDLE AGES.

Besides books, a lively exchange of letters was carried on between friendly monks, and there was never any lack of carriers, as there were always plenty of friars who preferred a roving life to the monotony of the cloister. The illustration, Fig. 6, represents this monastic messenger service. It is taken from the St. Meinard legend of the year 1466, now in the monastery library at Einsiedeln, which was printed by means of wooden plates. The text under the picture gives information in regard to the aim of the letter. The messenger comes from a monastery situated on Lake Zurich, and delivers a written request from his abbot to the one in whose monastery St. Meinard is active, to have this abbot reserve some celebrated teachers for his monastery.

Fig. 9.—A FRENCH POST OFFICE IN THE TIME OF LOUIS XV.

It was the flourishing period of scholarship and writing in the middle ages. Parchment had become the material for common use, and it was written and painted upon with skill. Another illustration, Fig. 7, leads us to a somewhat later period, equally interesting, namely, the writing cabinet of a crowned head of the fifteenth century.

In addition to the monasteries, the universities carried on a messenger service of their own. During this period the mail had rather a deplorable existence, and it did not thrive even in cities, where active industry ought to have awakened a necessity for it.

From Strassburg we learn that a messenger service did exist, but the city was continually quarreling with its bishop about the number of messengers with which it had to supply him. From other cities we hear of mails being carried by butchers; and as they were the richest persons, and traveled continually around the country, they appeared to be the most suitable and reliable for such a business.

In the large states of Eastern Asia, the delivery of the mail was an improvement upon this means. We are indebted to Marco Polo for important information concerning the mail in the Kubla-Khan empire. In addition to the news, this postal service brought the most expensive dainties from the boundaries of the empire to the chief city, for the grandee's table, and with a rapidity that was incomprehensible to a Venetian. In Japan the forwarding of the mail was intrusted almost exclusively to foot messengers. Two men usually ran together. One carried the official packet, usually folded tightly in a bamboo case, while the other carried a lantern in his hand. Our picture (Fig. 8), which is taken from the original Japanese, gives a true representation of this service in all its strangeness, and even the manner of folding the packets can be distinguished.

Fig. 10.—KURBRANDENBURG STAGE, SEVENTEENTH CENTURY.

Naturally, the postal service should be strictly centralized. Consequently, it could attain no true development so long as the empires of the middle ages were divided into a series of more or less independent states held together only by a loose feudal system.

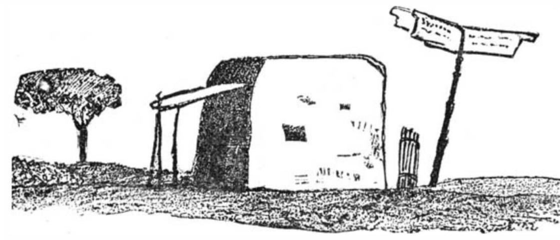


Fig. 11.—OLD POST OFFICE IN INDIA.

France was the first to attempt a uniform postal organization. Of course, the business was purely voluntary, and carried on without the least consideration for the public. Nevertheless, the postal system turned out to be a lucrative source of revenue to the state, and a benefit to the country. Under Louis the Fifteenth it had reached quite a respectable condition.

Our picture, Fig. 9, represents a post office in the time of this king, and one can see it gave almost the impression of a mercantile business. The postage was unreasonably high, and the secrets of letters were respected so little that only a very few ever thought of taking the trouble to close their letters, but simply fastened them together with needles, for one knew Richelieu's sentiments, viz.: "Sire, if one wishes to know what there is in a letter, *eh bien*, one must open it and read."

Thus, by leaving letters open, quite a little trouble was spared to the officers.

Fig. 12.—CONGO POSTMAN.

As is known, the office of postmaster-general in Germany and Spain was committed to the Thurn-Taxis family, which did much to animate and improve the establishment, but there was great room for improvement.

The arrangements for transporting passengers appeared to be especially deficient. Traveling was exceedingly expensive, and the roads were in a deplorable condition. The Kurbrandenburg stage, represented in Fig. 10, was by no means a model of comfort, but it was at least quite an improvement upon the "hauderer;" for when the traveler for pleasure formerly went in this conveyance, he was made a victim of discomfort and could reach his destination only in company with all kinds of packages, to say nothing of being penned in with many suffering companions.

Since then, although two centuries have not yet elapsed, the mail has made all elements subjective. It sends messages by the steam horse, on the wings of the wind through the tubes of the pneumatic post, and

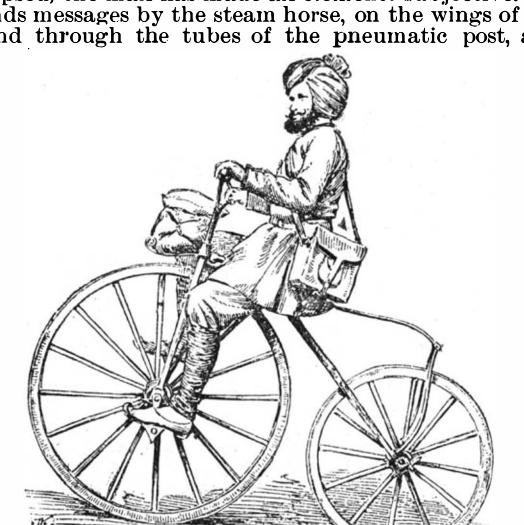


Fig. 13.—VELOCIPEDE POSTMAN, BRITISH INDIA.

across the sea with unfailing safety. Indeed, there is apparently no place on the inhabited earth, however remote, but is now accessible to the mail.

Whenever a European settles anywhere, he is first concerned about the post office that is to put him in connection with his native country.

Fig. 11 represents an exceedingly primitive post office in the interior of India, and from various other illustrations from life that we give, one can form an idea of the advancement that has been made in the postal system. In the Congo region the mail carrier, as shown in Fig. 12, is still obliged to go on foot, and the distances are so great that civilization has hardly yet begun to reap any profit through these messengers, who carry letters by fastening them to the end of a long stick. This reminds one a little of the Japanese style in the middle ages, Fig. 8.

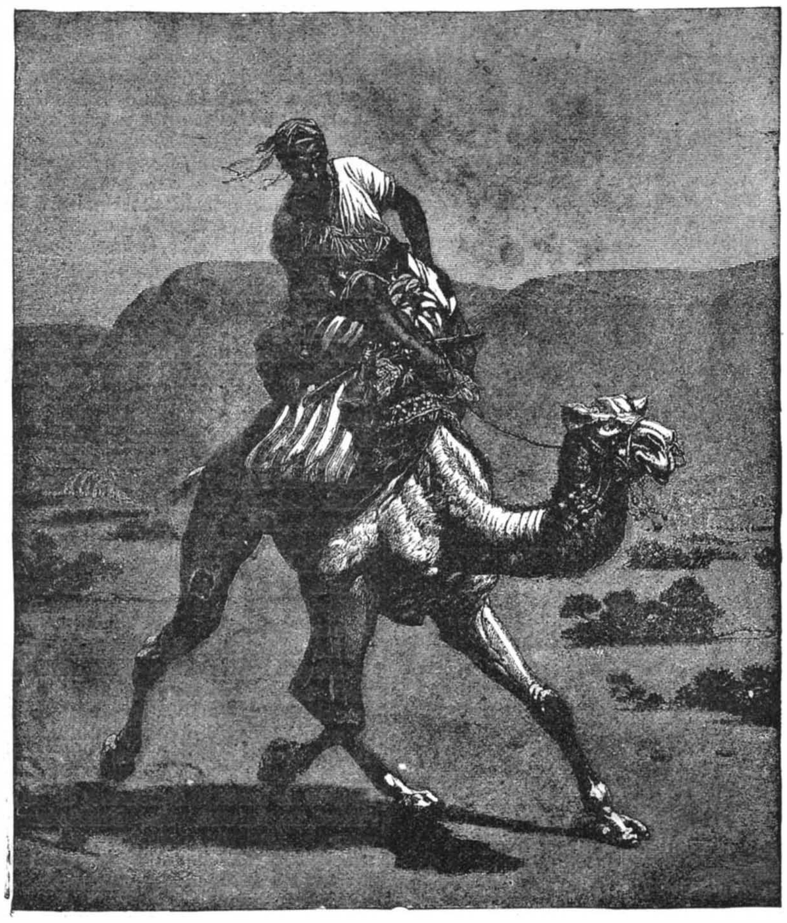


Fig. 14.—CAMEL POSTMAN.

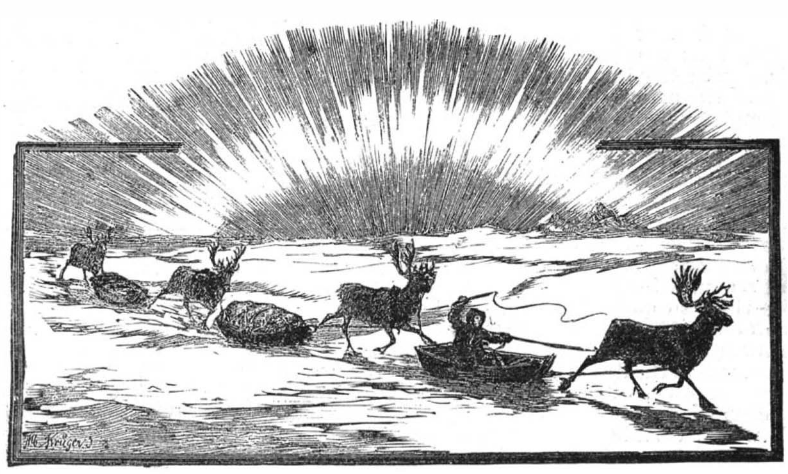


Fig. 15.—REINDEER POST.

In British India, however, the velocipede assists the mail carrier (Fig. 13), the camel (Fig. 14) carries the mail safely through all the terrors of the desert, and the reindeer (Fig. 15) helps to overcome the icy regions of the north pole.

The ice boat (Fig. 16) glides like an arrow over frozen portions of the sea, and is the means of carrying on business during the greater part of the year between Kiel and Korsoer, being always laden with packages and passengers.

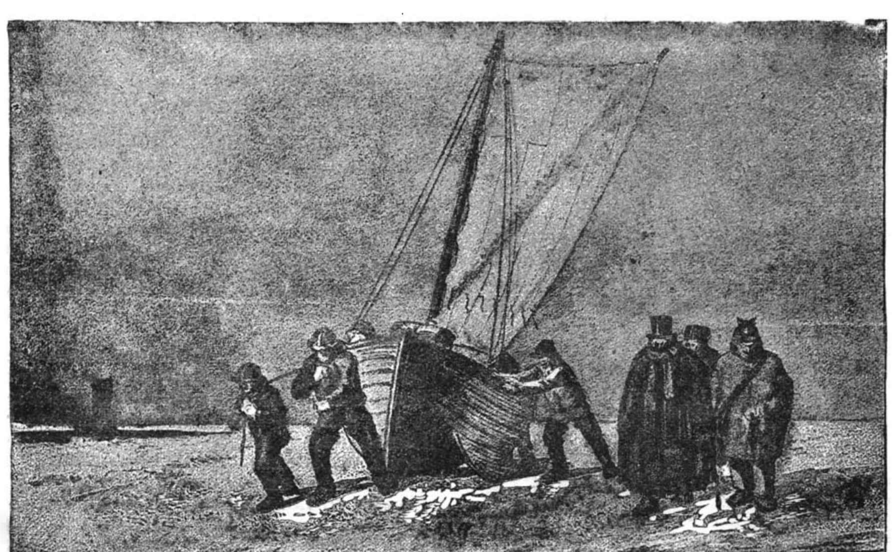


Fig. 16.—ICE BOAT POSTAL SERVICE.

Besides these visible servants, the mail has its invisible messengers. The electrical current is its subject. It glides over vast tracts of land with the rapidity of lightning, and in the cable it shoots through roaring waters. The mail and the telegraph are to-day inseparably related to each other, and one can only guess at the advance that the mail of the future will make in union with electricity, that great power whose sway will not be fully developed until the coming centuries. The mail has unfolded wonderfully within the short space of a generation, and promises to become still more potent.

Within the last three centuries much has been done toward improving the postal service. The Italian nobleman, Torriani-Tassis, who was raised to the dignity of an imperial prince under the name of Thurn-Taxis, instituted an important reform in 1516, by introducing a postal service between Vienna and Brussels, which was afterward extended as far south as Rome and as far north as Hamburg.

The efforts of individual states are also worth mentioning as regards the gradual reduction of postage, which was excessively high. At the instigation of Rowland Hill, England was the first to establish the foundation for a uniform postage, and the German tariff union copied the idea and extended it. But all reforms remained limited to territorial boundaries. It was reserved for the Bern compact to create a universal postal system that should be accessible to the entire globe, whereby all territorial obstacles disappeared. It was signed on October 9, 1874, became valid July 1, 1875, and in the year 1878, at the second convention in Paris, the union went into full power, with the name "World's Postal Union," and it literally embraces to-day the entire globe with the exception of China, Cape Colony, and Australia, but even these are accessible to the Union through the numerous post offices of foreign states.

Distance has ceased to be a hinderance to epistolary intercourse, as far as cost is concerned. Within the present century, a letter from Frankfort on the Main to Dantzic cost 15 groschen, or 37 cents of our money, while day letters from Germany to any inhabited part of the globe, excepting the three countries mentioned, cost but 20 pfennige, or 5 cents, and in consequence of this the exchange of mail has become nearly tripled during the twelve years of existence of the universal postal system. The mail had an important ally in the telegraph, and made enormous progress after Wheatstone succeeded in bringing about a practical use of the electric telegraph, followed by Morse, who improved the manner of conducting telegraphy by his writing apparatus, and Hughes by means of his type printer.

To-day the telegraph wires run through the whole world, and the mail is, with but few exceptions, everywhere employed in connection with the telegraph.

The mail must naturally have an extraordinary capacity of transformation peculiar to itself, in order to be able to perfect its task. It hastens to make use of every invention. In this connection we are reminded of the manner in which the German mail made use of the telephone, and yet it is conservative, for it uses even to day the old fashioned means of forwarding mail, instead of the most advanced means of communication that are offered in these modern times.

(To be continued.)

INTERESTING ETRUSCAN REMAINS.

One of the most important excavations of modern days was made at the end of November and the beginning of December. In fact, the interest it has excited has not been surpassed in Umbria since the life size bronze statue of Mars, in helmet and full armor, now in the Vatican Museum, was unearthed forty-five years ago.

The present excavation is at the burial place of a noble Etruscan lady, a few paces outside the Porta Fratta. Numerous fragments of pottery, etc., found near, led the brothers Orsini, to whom the land belongs, to search with care for any relics of value.

To this care is owed the remarkable state of completeness in which the gold, bronze, and terra cotta ornaments have been taken from the earth overwhelming a case of wood that had inclosed the remains of the body of a woman of rank—perhaps, as it has been suggested, that of a priestess. The wooden case had entirely perished from lapse of time, leaving only the clasps and beaked decorations to show its former existence.

Hopes are entertained that the written characters, some fourteen or fifteen in number, inscribed on the face of an immense gold ring, may provide a key to the name or dignity of the lady. The style of the vases and bronzes points to a period about 600 years before the Christian era.

The cranium of the lady is placed among the rest of the treasures found, and has the usual very low forehead of the Etruscan type. The ear pendants, between four inches and five inches in length, are larger than any hitherto discovered, except, perhaps, a pair in the British and another pair in the Perugia Museum. They have upon them a female head, and three delicate chains suspending tassels, all of fine gold.

The objects worthy of special mention are the following: A tripod used for burning perfumes, supported on three winged female figures in various attitudes, all with arms extended before them, except one, who places her left hand on her head. Above, upon a circle or wheel ornamented with four inverted *fleurs de lis*, stands a long-tailed satyr, with head erect, apparently washing in a round dish two nondescript balls, which he is rolling up and down. His legs are stretched wide apart on two edges of the wheel. Half way up the stem is another winged female, and surmounting the whole is a square reservoir for the perfumes or unguents, bearing on each angle a swan in repose.

Next comes a statuette of Bacchus, standing, inclined in an easy attitude, with legs crossed in a fashion which recalls the celebrated marble faun at Rome; another Bacchus, supporting on his head a long and empty basket, with, over it, an ornamented shell; a curious little owl, which served as pinnacle to a broken bronze vessel found near the place where would lie the feet of the lady; and a most beautifully shaped small terra cotta vase of Greek appearance, with a male and female head back to back on the top.

A mirror, probably held in the right hand, was found behind the shoulder. A long ivory instrument, with a handle elaborately and tastefully carved with a ram's head; a purple and white glass scent bottle; and two single handled vases in terra cotta were also found.

The golden ornaments are very numerous. First is the above named massive signet ring, which has two full length figures impressed on it, and a star over all. The written word thereupon may, if it can be read, reveal to history what manner of woman she was whose grave is rifled to minister to our curiosity. The letters are quite distinct and clear.

There are also a brooch adorned with a female head; a beautiful medallion with an onyx stone center; a plain gold ring, rather broader than a modern English lady's wedding ring; another ring with an onyx stone revolving on a pivot; a pair of small, close fitting earrings; a triple chain of gold, in pattern like the Genoese filigree work, which was attached to the above medallion; twenty large gold buttons, half of them ornamented with a head and the rest with a star; 200 pieces of gold in equal sized fragments which had formed a long chain, and broken loose from the filament on which they were strung, and a quantity of garniture in the same precious metal which had been sewn on the lady's apparel.

THE NEW GOLD FIELDS OF SOUTH AFRICA.

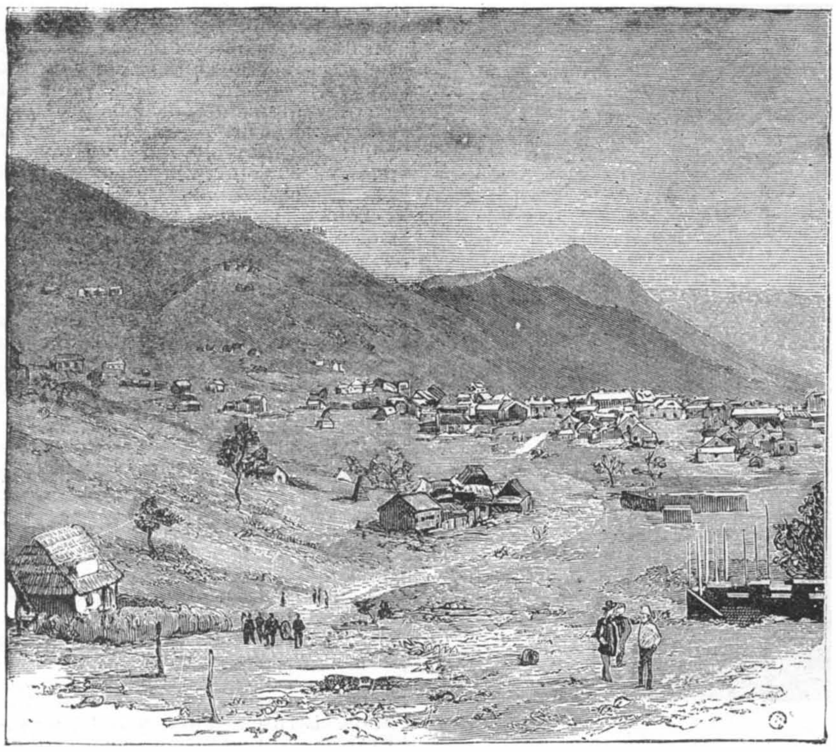
This auriferous tract, generally termed the De Kaap gold fields, is situated on the eastern side of the Transvaal, on the lower slopes of the Drakensberg Mountains, and about 120 miles from Delagoa Bay. The reefs are for the most part vertical, and run almost due east and west. For some years gold mining had been pursued with a tolerable amount of success in the Lydenberg district, but public attention was not strongly directed to this locality until the discovery of a valuable reef on Pioneer Hill, in 1883. This ground was at once secured by a Natal company for mining operations.

In 1884 several other gold bearing reefs were discovered, and in 1885 the Transvaal Government proclaimed the government lands as a public gold field. Messrs. Barber Brothers (from the Cape Colony) then discovered the Umcouchwa Reef, and gave their name to the mining township of Barberton, which has sprung up all around it. Soon after Messrs. Hillary Brothers found the Sheba Reef, and Messrs. Bray and Griffith hit upon Bray's Golden Quarry, containing gold bearing rock of exceeding richness. Parallel with the Sheba Reef, Messrs. Thomas Brothers, Cornish miners, discovered a spot of ground yielding very rich ore. After working it very profitably for some time themselves, they sold it to a company for £60,000 cash.

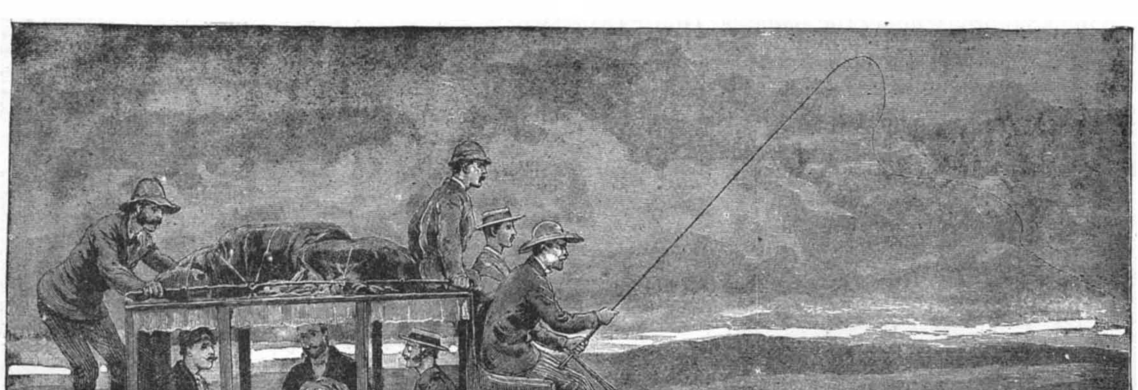
There are now numerous mining companies, formed under the limited liability law of the South African Republic, engaged in developing the mines of this district, with an aggregate capital of some £750,000, and there has been the usual amount of scrip broking and feverish speculation. The climate of the De Kaap district is excellent on the high lands all through the year, but the valleys are malarious after the heavy rains of summer.

Barberton, which two years ago had for its only building a tiny little shed, has now a population of over 2,000 persons, 300 houses, four hotels, a club house, two banks, and a newspaper. It has, however, a formidable rival in Eureka City, situated on the plateau above the Sheba Reef. There is little alluvial digging at De Kaap, and therefore it is not the place for a man who has nothing but a pick, a shovel, and a tin pan. To get gold in payable quantities capital is needed. Our engravings are from photographs sent to us by Mr. Thomas Foster, of Bicton Place, Exmouth, South Devon.

After describing his journey, which was performed partly by railway and partly by coach, from Cape Town to Pretoria, our artist says: "The coaches leave Pretoria for Barberton twice a week. They belong to Messrs. Dow & Co. The nearer the approach to the gold fields, the worse the road becomes. I traveled in the very worst season, the rain came down in torrents, consequently all the rivers were swollen, and we had to encamp in the open *veldt* before three of them. The Wilge River was deep, and the passengers inside had to take off boots, stockings, and trousers, and hold everything up to prevent it getting wet. At the Elands' River, the coach became entangled among huge bowlders, and a strong current threatened to sweep it away. The mules were urged with all the force that could be used, but were taken off their feet every time they attempted to move. All the passengers had to strip, and get to the river bank as best they could. At last the assistance of a span of powerful oxen was obtained, and with some difficulty the coach was hauled out, none of us being much the worse.—*London Graphic.*



BARBERTON, THE CAPITAL OF THE GOLD FIELDS.



THE NEW TRANSVAAL GOLD FIELDS—CROSSING THE WILGE RIVER, AFRICA.

MUSK.

The expected advance in the price of Tonquin musk became an accomplished fact at the public sales recently, when as much as 86s. per oz. was paid for good Tonquin pods, commonly known as "first pile." The enhanced value of the article is no doubt owing to the scarcity of good musk on this market and to the decreased shipments from China. It is not surprising, therefore, that reports should again be circulated, and generally accepted as true, that "the Mandarins," or whatever other functionaries are commonly supposed to control the executive government of the Celestial Empire, have ordered a close time for musk deer, with the object of affording that persecuted ruminant time for rest and multiplication. We question whether such a close time, supposing that it has been enacted, could be enforced effectively. The authority of the central government of China over the outlying portions of the empire, where the deer are mostly found, is known to be very shadowy, while the costliness of the article, and the ease with which it could be surreptitiously conveyed, would certainly place a premium upon poaching.

Moreover, China is by no means the exclusive home of the musk deer. Its habitat extends from the Altai Mountains on the Siberian frontier in the north to the southern slopes of the Himalayas, Assam, the Shan States, and Tonquin, thus covering vast tracts of territory outside the possible jurisdiction of Chinese game laws.

It is a fact that the finest pod musk is shipped from Shanghai, but it is quite possible that this port owes that distinction simply to its proximity to the Chinese town of Nanking, which appears for years to have been the central spot where the Chinese musk dealers received the yield of different districts, especially of the province of Se-chuen, and of Thibet. If, therefore, the Chinese government should place restrictions upon musk hunting, the trade route of the article might be diverted to Russia and British India, but it is quite likely that the supply would not sensibly diminish.

So long as musk remains one of the most prized perfumes, and commands an almost fabulous value on the European market, the musk deer is likely to be hunted down in spite of all restrictions, though probably, like the beaver and the bird of paradise, its entire extermination is only a question of years.

It is said that several attempts have been made to rear the musk deer in captivity, but in no instance has the experiment been successful. The habits of the creature are altogether opposed to the possibility of domestication. It inhabits the shady mountain forests, is seldom found at a lower altitude than 8,000 feet, but most frequently between 10,000 and 14,000 feet, its domicile bordering upon the region of eternal snow. It is not a gregarious animal, but lives in couples, mostly occupying its lair in the daytime, and roaming about at night in search of food. Add to this that the musk deer rivals the chamois in swiftness and climbing powers, and it will be seen that musk hunting is by no means a sinecure. The musk deer multiplies but slowly. The dam generally gives birth to one or two young once a year, which is another argument for the probability of the total disappearance of the animal at no distant date.

The following figures will convey an idea of the enormous number of deer slaughtered every year: In 1885 the quantity of musk shipped from Shanghai amounted to 2,266 catties, or 48,336 oz. A record kept by an American firm of musk buyers gives 394 grains as the average weight of the Chinese musk pods passing through their hands. Consequently, taking these figures as basis, a holocaust of 53,673 deer has been sacrificed to furnish the Shanghai exports for a single year! And this number only represents a moiety of the whole, for very large quantities of musk are exported through other channels, by way of Russia and British India.

The greater part of the Chinese musk pods offered in the London drug sales are very small, and have been taken from animals still far removed from maturity. The musk sac, which is carried by the male animal only, contains at first a thickish, pale colored fluid, which changes into musk about the third year. Under that age the animal is not worth killing, and even then it does not generally yield more than one-eighth of an ounce of musk. The average weight of the pod of a full grown animal is about nine-tenths of an ounce, though occasionally a specimen yields over two ounces.

Although exceptional circumstances may occasionally cause a temporary decline or an abnormal rise, the market value of musk is rising steadily year by year, and will no doubt continue to do so, unless a special cause should intervene.

Taking quadrennial periods from 1860, we find as the general market value of Tonquin pod musk in London:

In	January.		May.		September.
	s.	d.	s.	d.	s.
1860......per oz.	27		30		34
1864..... "	36		34		34
1868..... "	38		38		40
1872..... "	37		48		45
1876..... "	50		50		45
1880..... "	60	6	62		57
1884 .... "	77	6	72	6	73
1886..... "	74		77		78
1887..... "	86		—		—

These figures do not, of course, represent the highest prices paid in every instance—for on some occasions musk has realized over 100s. per oz.—but they give a fair idea of the general range of value.

These statistics strongly favor the view prevailing among experts that the regular market price of pod musk will ere long exceed 100s. per oz.

The principal causes which may possibly lead to a temporary depreciation of musk are to be found, we consider, in the annexation of Upper Burma by Great Britain and in the spread of Russian influence in Central Asia. It is thought that the former event will lead to an enormous expansion of European trade with the region of the Irawaddy and the southern provinces of China, and musk would in that case be not the least valuable product offered in exchange for our manufactures.

The same argument applies to the Central Asian highlands, for it is, no doubt, in those regions, and in the adjoining western portion of Thibet, that the deer yielding the variety known as Cabardine musk has its home. But the Cabardine musk, which finds its way to our markets, partly by way of the Chinese ports and partly *via* Russia, where it is extensively imported by the merchants visiting the Nijni-Novgorod fair, is not likely ever to approach the price paid for Tonquin musk.

Large quantities of grained musk are imported from British India. Much of this is utter rubbish, and reflects but little credit upon the exporters, but there are a few firms in India, such as Messrs. Symes & Co., of Simla, and a Nepal trading company, who supply a musk which can hold its own among the best.

The musk shipped from Shanghai is forwarded principally to London and Marseilles, although some consignments are occasionally sent to Germany. France is probably the largest consumer of musk in the world. She imported in 1880, 729¼ kilos. of the article, and re-exported 209 kilos. The average quantity imported into the United States is said to be 6,883 oz. French perfumers are among our best customers at the Lon-

don drug sales. They not only purchase fine pod musk in considerable quantities, but also manifest a peculiar affinity for empty musk skins and the trimmings of the pods, of which a few tins are occasionally offered in a condition anything but suggestive of

"The breeze that wafts o'er Oman's sea."

It has been imagined that, in the event of a cessation in the supply of Asian musk, a substitute might be found in the product of the American musk rat, or *Fiber zibethicus*, frequenting the marshy borders of North American rivers, and resembling the beaver in its habits. The "musk" yielded by this animal may be designated as a by-product, the creature being hunted principally for its skin, unlike its Asian fellow sufferer, of which no other part than the musk sac has any commercial value.

The American musk may be used for soap scenting and for some other purposes, though it is but a sorry substitute for the Chinese article at best. In the West Indies a species of rat, and in North Africa an antelope, have attracted the attention of musk dealers as possible successors of the musk deer. A few years ago it was reported that a consignment of musk derived from a Mississippi alligator (!) had been received in Germany. "The pods," we read, "were very small, and the odor slightly differed from that of true musk, being allied to civet, but the musk is suitable for perfumery." We have not heard of any development of the alligator musk industry. Perhaps its time has not yet come. We still have Tonquin musk, uncertain though the future supply may be, and sufficient unto the day is the evil thereof.—*Chemist and Druggist.*

THE UNITED STATES LABORATORY AT THE NEW YORK PUBLIC STORES, WITH A DESCRIPTION OF THE METHODS USED IN ANALYSIS.

By MARCUS BENJAMIN.

EIGHT years ago, at the September term of the District Court of the United States for the district of Maryland, the famous Demerara sugar case was tried. At that time the duties payable on sugar were levied according to the color, the Dutch Standard being the criterion by which the shade was determined. This standard was simply a series of bottles containing sugars of a known degree of purity, with which the imported sample was compared, and then accordingly classified.

For a year or more previous to the trial just mentioned, sugars that were supposed to be artificially colored or darkened had been imported into this country; but as it was almost impossible to satisfactorily prove such an assumption, no direct efforts to interfere with their introduction were undertaken. The use of the polariscope was agitated, and the matter carefully considered by the Treasury Department at Washington. Meetings of prominent merchants and importers were held in New York and other cities, and the subject was thoroughly canvassed. Finally, a large quantity of artificially darkened sugar was seized, and the trial at Baltimore followed. The jury decided, *first*, that "the sugars were artificially colored after crystallization," and, *second*, that "the importer introduced them with an intent to defraud the United States."

One striking fact was emphasized throughout all the testimony introduced, irrespective of the side by whom the opinion was advanced. It was that "there is no determinate relation between the color of sugars and their polarization or saccharine value." This consideration soon led to the issuing of an order by the Secretary of the Treasury, John Sherman, requiring the adoption of the polariscope for the examination of sugars in the customs service, with the gradual abandonment of the Dutch Standard as an authority. The sugar-importing ports were before long equipped with polariscopes and such articles as were necessary for the analysis of sugar and molasses. Portland, Boston, New York, Philadelphia, Baltimore, New Orleans, and San Francisco received outfits of chemical apparatus, and experts were detailed to prosecute the examinations.

The port of New York, which exceeds all the others combined in the value and variety of its imports, was selected as the best locality at which to establish a general chemical laboratory for the customs service, and it was deemed best that the chemical laboratory should be under the same general management as the sugar laboratory. In the latter part of the year 1878, Dr. William C. Tilden, who had recently acted as professor of chemistry at the Howard University, in Washington, D. C., was appointed in charge, and Mr. Edward Mayers, an expert who had given valuable testimony on the side of the government at the Baltimore trial, was selected to direct the sugar work. Rooms at 128 Hudson Street were hired, and the work was begun. Various analyses of opium, iron ores, alcohols, etc., etc., were carried on.

After a year's experience at the place mentioned, the amount of work having considerably increased, larger accommodations were necessary, and the U. S. Laboratory was moved to the corner of Grand and Varick Streets. In the meanwhile the force had been augmented by the appointment in 1879 of Dr. Jesse Park Battershall, a well known analytical chemist of New York City. This gentleman's experience and thorough chemical knowledge made his services a most valuable acquisition for the U. S. Laboratory. Dr. H. M. Baker, a gentleman whose familiarity with dyes and various coloring materials made his services desirable for the examination of the coal tar products then arriving at this port, had also been appointed for work in this new bureau. Dr. Tilden was subsequently removed, and, in May, 1880, Mr. Edward Sherer, a sugar chemist, was appointed to the control of the laboratory. Two years passed away, and again a removal took place. New quarters were found at 393 Canal Street, over the People's Bank. During the year 1881, 3,533 samples of sugars and of sirups or cane juice were tested by the polariscope, but in March of the following year a decision of the Supreme Court resulted in an order from the Treasury Department discontinuing the use of the polariscope and other chemical tests, and directing that such examinations be made simply by the Dutch Standard of color. The number of sugar determinations in 1882 were, therefore, comparatively few, being only some 771 in number, while for the year 1884 the number of polarizations increased to upward of 30,000.

The amount of work executed in the other divisions of the laboratory during 1882 was of great importance. It was estimated that $115,052.64 of additional duties were collected by the government, in consideration of the information derived from the chemical analyses furnished by Dr. Battershall, on three items alone, viz., oxides of iron, bone black, and iron ores. Valuable service was rendered by chemically determining the identity of the various dyes that were imported. Such determinations made possible the proper appraisement of the invoices, and thereby enabled the authorities to collect the just amount of duty. On June 1, 1883, the revised tariff law came into force. An increased amount of chemical work was one of the immediate results of its enactment. New employes, additional facilities, and greater space were at once necessary. The first of these requirements was provided for by adding to the force six examiners, some of whom were only accepted after a civil service examination. Among the latter were J. Howard Wainwright and the writer, both graduates of the Columbia College School of Mines.

By securing and fitting up specially for the U. S. Laboratory the building located at the northeast corner of Hubert and West Streets, the remaining difficulties were apparently overcome. The four floors of this building are in direct communication, forming, in fact, a part of the U. S. Appraiser's stores. The new offices were first occupied during the latter part of the summer of 1883, and it seemed as if at last the laboratory had secured a permanent home, but now the space seems too small, and complaint is made that the work is hampered by the lack of room.

Before describing the work performed in each of the three branches of the office, a few observations on the general functions of the laboratory will aid in explaining its field of operations.

It is the only general chemical laboratory connected with the U. S. Customs Service, and, therefore, various articles are sent to New York for chemical analysis from every other port of entry in the country. Important questions of a scientific nature are frequently received from Washington, demanding a careful investigation at the hands of the experts here in office. Among other duties are the preparation of reports for special agents. This work has frequently been of the greatest value in exposing frauds in importations. The amount of drawback is, whenever possible, determined by chemical analysis.

Besides the foregoing, reports of analyses are furnished to the following divisions of the appraiser's stores, on the subjects as herewith given:

4th Division—Silks and fabrics.
6th " —Wool and hair.
7th " —Dyes, drugs and chemicals.
8th " —Sugar.
9th " —Metals, ores, etc.
11th " —Groceries, teas, liquors, etc.

And, also, reports are furnished to the seventh division of the U. S. Custom House.

The upper floor of the building is the special domain of Dr. H. M. Baker. In this room the aniline dyes and colors are identified, the different fabrics examined and classified. Microscopic examinations of wools and hair are made, besides microscopic examination for the second division, and special investigations required by the appraiser.

The identification of various hairs forms an exceedingly interesting part of Dr. Baker's work. The specimens are received from the Sixth Division, and from a microscopical examination it is determined whether the material is goat's hair or camel's. At times samples of human hair have been tested. In the annual report for the year 1884, twelve quantitative goat hair determinations are recorded; four yak hair estimations are likewise mentioned. The color estimations are comparative examinations of dyed samples of wool prepared from standards in the possession of the laboratory, and of similar samples prepared from the specimen of dye under consideration. A visitor to Dr. Baker's laboratory will often see, drying, skeins of wool suspended from the ceiling, resplendent with all the brilliant colors of the magnificent coal tar products, rivaling in beauty and delicacy of shade an Eastern flower garden. The wonders of chemistry are before us, and, as we glance from the lump of crude tar or from the indifferent aniline oil to the exquisite loveliness of the eosine and many other dyes, we cannot but wonder if the chemist is not in some way related to the magician of olden times.

The floor beneath is devoted to the analysis of sugar. The work here performed is beyond doubt the most important, from a pecuniary standpoint, of all that is executed in the laboratory. The report for the month of March, 1885, reads as follows:

		Tests.
Number of samples tested in duplicate....		1567
Samples requiring a third test...........		65
Total number of tests....................		3199
Damaged samples tested..............	58	
Retests performed....................	84	
Comparative tests....................	22	
	—	164
Making a grand total of...............		3363

The annual report for 1884 stated that 132,022 polarizations of sugars and molasses were made. The estimated cost of this work if performed by expert chemists outside of the government employ was $16,011, while the actual expense to the United States for this work, including salaries, gas, rent, and apparatus, was only $12,142.13. A saving of $3,868.87 was thereby effected. A better appreciation of this work may, perhaps, be had from the statement that during the past year there was imported into New York 755,353 tons (2,240 lb. each), having an approximate value of $86,000,000, on which duty to the amount of not less $25,000,000 was paid.

About ten men are continuously engaged in the work of examining sugar. The crude article is received from the sampling room in tin boxes holding about one pound each. The sample or the contents of each box is thoroughly mixed by grinding in a porcelain mortar and is then handed to the weighers, of whom there are four. After weighing out 13·024 grammes, the standard weight taken, the samples are brought into solution with water in a 50 cubic centimeter flask. When the sugar is completely dissolved a few drops of lead acetate are added. Then the solution is increased exactly to 50 cubic centimeters by adding water, is well shaken and filtered, and the filtrate is poured into the polariscope tube. There are five polariscopes in constant use in the sugar room. They are of the Scheibler variety, and are made in Berlin, Germany. The law requires the examination of sugar to be made in duplicate, and an agreement to within three-tenths of a per cent. is necessary before a report of the saccharine strength of a sample can be made. This sometimes necessitates a re-examination of the sample, and frequently, when the sugar is a poor one, four or five retests are made before concordant results are obtained. Examinations of damaged samples of sugar form part of the work required of the experts in this room. Damaged sugars are those that have become injured during the sea voyage to this country. In addition to the polarization, a determination of the amount of moisture contained in the sugar is necessary. This estimation is made by weighing a quantity of the sugar in a porcelain dish, drying at 100° C. to constant weight, and again weighing. The difference between the two weights is the amount of moisture. Every month a series of so-called comparative tests are exchanged between the sugar-importing ports. These tests are simply determinations of moisture and of the saccharine strength by the polariscope, which are verified or "compared" by the receiving port. By this means any important variations in value of the instruments would at once be detected. Mr. Wm. D. Crumbie, one of the examiners connected with the laboratory at New York, tests all the sugar received at New Haven. He is telegraphed for at once on the arrival of a cargo of sugar. The examination of sugars is dispensed with for the present at Portland, Me. During 1884, only 13,380 tons of sugar were received at Portland, New Haven, and other Eastern ports.

Descending another flight of stairs, we reach the office and library. The latter is a comparatively well selected lot of working books. It contains sets of Watts' Dictionary of Chemistry; Leopold Gmelin's Hand-book of Chemistry as published by the Cavendish Society; Spons' Encyclopædia of the Industrial Arts; Ure's Dictionary of Arts, Manufactures, and Mines; Lippincott's Encyclopædia of Chemistry; Roscoe and Schorlemmer's Treatise on Chemistry, etc., etc. A complete set of the *Chemical News*, of London, from its beginning up to the present date is one of the few "treasures" in the book case. In all there are, perhaps, some hundred and fifty volumes, but as the laboratory grows the number of books will increase, so that the nucleus at present formed may be the basis in time of a valuable part of the laboratory.

The remaining branch, a description of which will complete the sketch, is under the immediate charge of Dr. Jesse P. Battershall, who studied in the Columbia College School of Mines, and subsequently received the degree of Doctor of Natural Philosophy at the University of Tubingen, Germany, for original investigations in the chemistry of naphthaline series. Dr. Battershall is assisted by Mr. J. Howard Wainwright, Ph. B., F.C.S., a graduate of the Columbia College School of Mines, Dr. J. Frank Davis, who was graduated at the Bellevue Hospital Medical College, and Mr. Ernest G. Chapman. The laboratory, which is a moderately well equipped one, contains several scales, including two of Becker's most delicate balances, on which it is possible to weigh within one-tenth of a milligramme; an excellent assortment of platinum ware, including the large evaporating dishes used in the determinations of ash in the tea assays; a Scheibler's carbonic acid apparatus; well arranged water baths for evaporation, on which at times upward of a dozen determinations of morphine are being carried on; blast apparatus; Fletcher's burners; combustion furnaces for organic analysis, and other conveniences too numerous to mention.

The character of the work is, naturally, somewhat varied. It includes assays of tea, of drugs, such as opium, quinine, jalap, and similar substances, analysis of lead ashes, various alloys, iron and copper ores, determinations of alcohol in wines, spirits, tinctures, and other preparations of drugs, also examinations of glycerine, kainit, and many other qualitative and quantitative estimations for customs purposes.

The unsatisfactory nature of the teas brought into the United States led to the passing of an act by Congress prohibiting the importation of "any merchandise for sale as tea, adulterated with spurious or exhausted leaves, or which contains so great an admixture of chemicals or other deleterious substances as to make it unfit for use." In consequence of this act, all teas are now analyzed at the United States Laboratory. Those samples which fail to comply with the requirements cannot be entered in this country, and they are reshipped and sold elsewhere. During the year 1884, upward of seven hundred examinations of tea were made, and this number has steadily increased since.

The tea assays, which are made by Dr. Davis, consist of the following determinations: Total ash, ash insoluble in water, ash soluble in water, ash insoluble in acids, extract, insoluble leaf. The method of analysis followed is the one devised by Dr. Battershall, and described by him in his translation of "Naquet's Legal Chemistry."* The general outlines of the processes are as follows: *Total ash.*—Five grammes of the sample are placed in a platinum vessel and heated over a Bunsen burner until complete incineration has been accomplished. The vessel is allowed to cool in a desiccator, and is then weighed as quickly as possible. In the United States tea adulteration law, a maximum of eight per cent. total ash is allowed for the leaf. *Ash insoluble in water.*—The total ash obtained, as previously mentioned, is washed into a beaker and boiled with water for a considerable time. It is then placed upon a filter, and the insoluble residue washed, dried, ignited and weighed. *Ash soluble in water.*—The proportion is obtained by deducting the ash insoluble in water from the total ash. The ash insoluble in water is boiled with dilute hydrochloric acid, and the residue separated by filtration, washed, ignited, and weighed. *The extract.*—Two grammes are boiled with water until all soluble matter is dissolved, water being added from time to time to prevent the solution becoming too concentrated. The liquid is poured upon a tared filter, and the remaining insoluble leaf repeat-

* Tea and its Adulterations, p. 134 *et seq.*

edly washed with hot water until the filtered liquid becomes colorless. The filtrate is now diluted to a volume of 200 c. c., and of this, 50 c. c. are taken and evaporated in a weighed dish, over the steam bath, until the weight of the extract remains constant. Its weight is then determined. *Insoluble leaf.*—The insoluble leaf obtained in the preceding operation, together with the weighed filter, is placed in an air bath and dried for at least eight hours at a temperature of 110 C.; its weight is then determined.

It should be noted that in the foregoing estimations, the tea is taken in the ordinary air-dried condition. If it be desired to reduce the results obtained to a dry basis, an allowance for the moisture present in the sample (an average of eight per cent.) must be made.

The opium assays rank next to those of tea in point of number. All of this substance that is brought into the United States must contain at least nine per cent. of morphine. Frequently twenty or more samples from a cargo are received at the laboratory. During the month of April, 1885, there were 108 estimations of morphine received. Hence, it was necessary to adopt some method which could comply with the following conditions: rapidity of manipulation, simplicity of apparatus, and accuracy of results. Mr. Wainwright undertook the solution of this problem, and after careful study of the different processes in use, devised a method slightly modified from that recommended by Dr. E. R. Squibb.* The assay consists of three distinct operations: first, preparation of the extract; second, separation of the morphine; and third, treatment of the separated alkaloid.

Preparation of the Extract.—Ten grammes of the sample are introduced into an ordinary six ounce wide mouthed bottle, fitted with a good cork. Then one hundred c. c. of boiling water are added, the bottle tightly corked, and after frequent hard shaking allowed to stand from twelve to twenty-four hours (generally overnight). The extract is then decanted upon a filter, 50 c. c. of hot water is added, the bottle again well shaken, and its contents transferred to the filter. When the liquid ceases to drop, the contents of the filter are put back into the bottle, again shaken with 50 c. c. of water, after which it is thrown upon the same filter, and washed until the water comes through colorless. The filtrate is now concentrated over a water bath to a volume of about 25 c. c. This extract is then transferred, using as little water as possible, into an accurately tared Erlenmeyer flask, provided with a tight cork, and allowed to stand. *Separation of the Morphine.*—After cooling. 10 c. c. of 95 per cent. alcohol are added and the flask agitated; then sufficient ether is added, the cork tightly fitted, and the flask again well shaken. After this, and before the ether has had time to separate, about 4 c. c. of a ten per cent. solution of ammonium hydroxide is poured in. The flask is then well shaken until the crystals of morphine begin to separate. It is then set aside in a cool place, until the alkaloid has entirely separated (generally overnight). *Treatment of the Separated Alkaloid.*—When the separation is complete, the upper portion of the ethereal fluid is carefully decanted through a tared filter; then 20 c. c. of ether is poured into the flask, and after slight agitation carefully poured on the filter. The paper is washed with more ether, applied drop by drop around the edges. The crystals remaining in the flask are then washed upon the filter with cold water, and the washing continued until the filtrate comes through colorless. The filter and contents are then pressed between folds of blotting paper and dried in an airbath at 100° C. The tared flask is likewise dried and weighed if any crystals adhere to its side. Weighing and calculating results complete the operation.

In the analyses of lead ashes and alloys, the usual methods of separation recommended by Fresenius and others are used. The copper matte and ore estimations are made by the ordinary electrolytic method. With iron oxides a simple determination of the oxide is all that is considered necessary. This is accomplished by means of precipitation with ammonium hydroxide and subsequent separation. Under this head may be included various pigments, such as colcothar, crocus martis, Indian red, and similar compounds; also the polishing powders, with various names, on which duty is levied according to the amount of iron oxide contained in them.

Examination of substances containing alcohol includes the determination of the amount of absolute alcohol by distillation, and of the specific gravity of the distillate. The examination of glycerine is somewhat crude, although in the hands of those who have had experience in the matter it becomes very easy to determine whether the sample under inspection is raw or refined, as the duty is regulated according to the quality of the glycerine. The assay includes the following tests: 1. The reaction with litmus paper. 2. Determination of the specific gravity. 3. Examination of the precipitate with silver nitrate, lead acetate, barium chloride, and ammonium oxalate. The determinations of the carbonaceous residue and of the mineral ash also are made. The vinegar determinations which are daily made consist in taking the specific gravity of the sample, and in ascertaining the number of grains of potassium bicarbonate required to neutralize one troy ounce of the fluid. Phenolphthaleine has been used as an indicator, and gives every satisfaction.

The examination of kainit, potassium sulphate, and manure salts is frequently required. Large amounts of these substances are imported from Germany. The method† followed consists in dissolving ten grammes of the sample in 200 c. c. of water, and after diluting to 1,000 c. c., and filtering, 25 c. c. of the filtrate is diluted to 150 c. c., and a slight excess of barium chloride is added. Then, without filtering, barium hydroxide is added in slight excess. Filter and wash until the precipitate is free of chlorides. To the filtrate add 1 c. c. of strong ammonium hydroxide, and then a saturated solution of ammonium carbonate until excess of barium is precipitated. Add in fine powder 0·5 of a gramme of pure oxalic acid or 0·75 gramme of ammonium oxalate. Filter, wash, and evaporate the filtrate to dryness. Then ignite until all volatile matter is driven off. The residue is digested with hot water, filtered, and diluted to 30 c. c. To the filtrate two drops of strong hydrochloric are added, and then 10 c. c. of a solution of 10 grammes of platinum chloride in 100 c. c. of water. The mixture is evaporated to a thick sirup over a water bath, treated with 85 per cent. alcohol, well rubbed with the stirring rod, washed with 85 per cent. alcohol by decantation, collected on a filter, again washed with alcohol, dried and weighed.

In addition to the foregoing the chemist is called upon to examine numerous compounds which have been entered under the names of "chemical salts," "medicinal preparations," "acid bases," "no name," and similar titles. A curious illustration of the latter occurred in an undesignated compound, which was apparently a mixture of chalk and some organic body. The determination of the character of the latter for some time baffled the examiner, until, after testing it, the numbness produced on his tongue suggested cocaine, a theory which was subsequently corroborated by the proper tests.

Questions of the gravest importance, involving thousands of dollars of duty, are often referred to the laboratory for consideration. The opinion given is sometimes questioned, and its correctness must be defended in open court. This requires considerable research on the part of the chemist, as well as a high degree of competency. During recent years the most notable of these cases was a series involving the correctness of the chemist's report of the analysis of colcothar, and later several questioning the accuracy of his results in analyses of bone back. Frequently subjects dealing with chemical technicalities are referred to the chemist for consideration. Of this nature was the important decision which turned on the question as to whether Apollinaris water was natural or artificial. These questions, though usually of less prominence than that previously referred to, are sent to New York from every port of entry in the United States; and according to the report received, the amount of duty to be levied is fixed. From the description thus given of the work accomplished by Dr. Battershall and his assistants, some idea of the scope and magnitude of the United States Laboratory may be obtained.—*American Analyst.*

* Ephemeris, vol. i., p. 15.

† See "Methods of Analyses of Commercial Fertilizers." Bulletin No. 7, Department of Agriculture. Washington, 1885.

BLUE PRINTING.*

In the first place, pure and fresh chemicals are essential to the production of fine prints, and a paper that is not too heavy, with a smooth, hard surface, and pure white in color. This being secured, it is then necessary to prepare a sensitizing bath, which is made as follows: One ounce of red prussiate of potash dissolved in eight ounces of water; one ounce of citrate of iron and ammonia dissolved in two and a half ounces of water.

These solutions are to be kept in separate bottles, the potash to be kept in the dark until wanted for use, when enough for the amount of paper you wish to sensitize is mixed in the proportion of one part of iron solution to two parts of potash solution, it requiring one ounce of the mixed solutions to prepare one square yard of paper. My manner of preparing the paper is to lay it flat on a clean, smooth surface, preferably glass, and apply the solution with a small soft sponge, which is dipped in the solution and about one-half of the contents squeezed out. It is then passed over the paper from one side to the other until the sheet is covered, and then the sponge is dipped in the solution, again squeezed out, and passed over the sheet again at right angles to the line of the first application. In sensitizing be careful not to use too much solution, for the result is streaks in the print. When properly done, the paper will present an even golden color.

The paper is then dried in the dark, and the sooner it is printed after it is dry the purer will be the whites in the print and the richer will be the color.

In printing on the paper, it is necessary to print much darker than with silver paper, printing until the deepest shadows have assumed a gray color and all or nearly all the detail has disappeared, and the high lights in the picture are a light blue color. Then remove the print, when it is to be washed in clean water until when hung up to drain the last drops of water from the corner of the print are perfectly clear. If they show a tinge of yellow, the print must be washed again. If the highest lights or sky in the picture are perfectly white, it will deepen the color to immerse the print in the following solution for a few seconds:

Saturated solution of sulphate of iron	4 ounces.
Sulphuric acid	4 drachms.
Water	4 ounces.

Should the high lights be in the least clouded or the print not thoroughly washed, this solution should not be used, as in either case it will give the whole of the print a blue tinge. It would, perhaps, be best as a general thing to use a solution of

Acetate of lead	2 ounces.
Water	8 "

which will give almost the same tone, provided you have printed dark enough. Should your print be light or weak, the latter bath will give a reddish purple tone, which is not very pleasing.

If the taste of the printer should incline to green, a beautiful green color can be had by printing a little lighter than usual and immersing the washed print in a solution of

Water	8 ounces.
Sulphuric acid	½ drachm.

A great many experiments have been made by myself and others, with the object of obtaining a black print from the blue, but with only partial success, however; the nearest I have come to it is a very dark reddish black, which, when the print is wet or varnished, changes to a deep wine color. It is produced by immersing the print after it has been washed in a solution of

Tannin	1 drachm.
Water	4 ounces.

Leave in this solution for five minutes, then change the print to a solution of

Carbonate of soda	1 drachm.
Water	4 ounces.

Leave in this solution for one minute, then change back to the tannin solution.

Repeat this for five or six times, or until the print has assumed a deep wine color, when it may be washed and dried, and when dry will be almost black. This process has the objection that the whites are never pure, but have a slightly reddish stain. A very dark gray, almost black tone, may be had by immersing the print in the soda solution first, allowing it to remain until the print has almost disappeared and is a dirty yellow color, then wash and immerse in the tannin solution, leaving it for four or five hours. When dry it will be a very dark gray with a slight red tinge.

In regard to the last two results, I will say that the blue print is, in my estimation, by far the nicest, being more brilliant and having clearer lights, and is much easier and quicker done. The black prints will not be of much service, except as an experiment in photography, until one is produced equal in brilliancy and color to a bromide print.

If the blue print is thoroughly washed and placed in the above tannin bath for a few minutes, then changed to the soda bath until the color has just changed, no longer, then change to the tannin solution, and repeat two or three times, a very fine sepia tone is obtained, which is equal fully to a silver print; but care must be exercised not to allow the soda solution to act too long.

After your blue prints have been well washed and treated to either of the toning baths, it will improve the whites and also add to the permanency of the print to dry them in the full sunlight, tacking them face up to a board and laying them out in the air where the sun will shine directly on them.

Let me say again, if you wish to be successful and obtain clear, bright prints, get good fresh chemicals and use freshly prepared paper.

If the potash, either the crystals or the solution, should have a green tint, it is not good and should not be used. It should have in solution a bright wine color, and a crystal freshly broken should present a light scarlet color. The iron should be obtained in sealed bottles of one ounce each, and if kept corked and sealed will be good until used.

I wish also to say that the methods of toning prints, as given, are only vouched for in connection with the sensitized solution given. With other formulæ and ready sensitized paper I have had but little experience, and do not know how the different solutions given for toning would operate with them.

The finished print may be mounted in any convenient way to suit the person most concerned. It is only necessary to avoid contact with any of the alkalies, as they all destroy the color. F. R. C. Perrin.

* A communication to the Pittsburg Amateur Photographic Society.

SUGGESTIONS ON TEACHING GEOLOGY.

By W. Edgar Taylor.

Before organizing permanently a class in geology, carefully prepare and adopt some successful and systematic plan of work. When a carefully arranged plan is decided upon, adhere to it in every particular unless convinced some changes are highly important. Give the pupils a short and concise outline of work to be done, and select a parallel course of reading and work for yourself, that the interest of the class may be simulated by the enthusiasm of the teacher. Do not attempt too much. See that all your exercises are arranged with special reference to some logical and systematic plan. When at first beginning a prime division of geology, require a strict adherence to the discussion of the text-book matter or plan of work decided upon at the outset. Afterward give them as much laboratory work as the time will permit, to be followed by a prearranged parallel course of reading bearing strictly on the work in hand. Reviews should be characterized by diagrams, outlines, sketches, reading, and other well known methods of work. There should be a large amount of laboratory and field investigation, all of which should be accompanied by careful and neat sketches or drawings or both.

We prefer to have pupils begin laboratory work with minerals. Do not select specimens from distant parts of the country, but use the commonest minerals to be found. For the first exercise the teacher should secure a large bowlder or collection of minerals of same material and with special reference to class work for the pupils to work upon. After seating the class around the tables, give each a specimen. Have each member make a close, careful, and separate examination and present a written report with the specimen to the teacher. These may be examined immediately or after the exercise. The student's report should state all the facts on which the name of the specimen depends. These exercises should be continued until each pupil is able to classify the commonest minerals. Some few exercises may be given in the field by the teacher, after which the pupil may be required to collect, classify and label a private collection of his own. After collecting and classifying the commonest minerals in his own vicinity, the pupil may be encouraged to make collections from various sources and prepare a small cabinet. Every pupil should be supplied with a good pocket lens, costing from 75 cents to $1.25, an old hatchet or small hammer or, what is still better, the paleontologist hammer and a hard sharp piece of steel answering the purpose of a hardness tester. For a convenient method of preparing mineralogical slides we recommend the following from Prof. P. S. Ash:

"Chip off a flat piece of the specimen at least 1½ c. c. square, then rub down one side on a piece of wrought iron 20 c. c. square with coarse emery until one surface is nearly plane, without holes or cracks; then rub on a plate of glass of the same dimensions, one side of which is ground, not polished, with flour of emery, and make the surface of the specimen as true as possible. Then clean well with a stiff brush and water. Now take a little Canada balsam and boil it in an iron spoon until a drop of the balsam will, when cold, be hard enough to resist the pressure of the finger nail, without being brittle. With this balsam cement the ground surface of the specimen to a piece of glass 2·5 c. c. square, care being exercised to have the specimen perfectly dry, and to prevent the formation of any air bubbles, as this would cause the specimen to break when ground down very thin. After this is cold, grind the other side down in the above named manner, until you have the specimen sufficiently transparent. Now clean the slide well, taking off all the balsam from around the specimen with a fine knife, wash well with water and a stiff brush, and dry the slide well. After

dry, with a little balsam cement a cover to the slide, and let the balsam set. After the balsam is perfectly dry, clean the slide well with spirits of turpentine, put your label on, and the slide is finished.

"Sometimes the glass slide will be scratched, and if you desire a first-class slide you can transfer the film to another clean glass by gently warming the slide until the balsam gets soft, and with a fine needle you can remove the film to a new, clean glass, upon which has been dropped one or two drops of the above Canada balsam, and then finish the slide in the above named manner."

In the study of fossils the work may be pursued very much on the plan followed in the study of minerals. Only such fossils as are typical of some class or formation may properly demand the careful study of the class. A well developed system somewhat on the plan of teaching botany or zoology should be carefully followed. As an illustration we quote the following from a lesson on cup corals. A part may seem a repetition, but will perhaps contain additional points.

"First study their external characters. The whole specimen is sometimes called a *cell*. It is also known as *polypary*. You notice at the larger end a depression, giving the coral the appearance of a cup. This is called the *calyx* or *cup*, plural *calyces*. The adjective which expresses some relation to the cup is *calycinal*, as *calycinal extremity*. Sometimes we find a pit in the bottom of the cup on one or two sides. This is a *fossa*, *fossette*, or *fovea*. The exterior of a perfect specimen is generally covered by a skin like covering called *epitheca*. This in some species is smooth, but more frequently is transversely *wrinkled*. Under the epitheca is the *wall*. When the epitheca is wanting or has been worn off, we often see numerous white lines running lengthwise of the coral. These are *costae* or ribs. In the cup may be seen a set of radiating raised lines which look like the upper edges of radial plates. These extend from the outer wall toward the center. These are generally called *septa*. Next let us study the interior. To do this we may make a transverse section. The surest way to avoid spoiling the specimen is first to file a groove around a calcareous fossil with a three-cornered file. Break and grind one of the broken surfaces flat and smooth and polish it. You may first use the flat side of a grindstone or you may use emery and water on a flat surface of lead, copper, or iron. Next you may polish the surface on a hone, or you may do it with emery flour on a piece of plate glass six or eight inches square. The finest polish may be used with dry emery slime on a piece of buckskin tacked to a smooth board. When a transverse section of your cup coral is thus polished, it shows a beautiful internal structure, which you can examine with a lens, and of which you may make drawings.

"But it is possible to do even better than this. You may procure a very thin transverse slice, so thin that light passes through it, and the whole internal structure will be perfectly shown." (This part is very much like the quotation from Prof. Ash, and we omit.)

In studying physiographic and what may be called formative geology several methods may be followed to great advantage. Much may be gained by taking the class into the field and discussing the formation and drainage of the country, such as hills, valleys, and streams. The various effects of water and atmosphere will be found abundantly illustrated in any country. If convenient, some Saturday afternoon may be spent with profit and pleasure. In connection with field work much time may be profitably spent in map drawing, not for the sake of drawing itself, but for impressing on the minds of the pupils forms of special importance. Map drawing may be begun by copying from a reliable text-book, but after a short time classes should be able to make drawings of sections from descriptions and maps.

Drawings showing the outcroppings of formations, the salt beds, coal fields, oil beds, and their economical features will be found of interest. A very profitable and interesting exercise for a class would be to carefully make a map of their own State. If sufficient time be given to the study of geology, much time may be spent profitably in mounting wall maps on cloth. No teacher can interest a class in geology without first interesting himself. Neither can a teacher, however skilled, awaken an interest by class recitation alone. Skillful laboratory drill and field work are indispensable to success in teaching geology.

Young teachers in preparing lessons for classes in geology would receive great help from Le Conte's Elements of Geology, Dana's Manual, Shaler's Geology, teacher's edition, geological maps of Colorado and other maps published by the Government, Dr. Winchell's two books, Sketches of Creation and Geological Studies. To the last named the writer is largely indebted in the preparation of this article.—*Naturalist Gleaner.*

SWEET-SCENTED FERNS.

By W. H. GOWER.

WHILE some plants are valued for the brilliancy of their flowers, others are scarcely less appreciated for their agreeable fragrance, and a third class, in which are included the ferns, depend for their popularity upon the grace and elegance of their fronds and their vivid shades of green. Among ferns especially, few would expect to find sweetness in the way of scent, yet some few members of this family have this additional charm. The following, therefore, are a few which may claim to be designated sweet-scented: Lastrea æmula, the hay-scented buckler fern, a robust growing plant, has a stout, creeping root-stock, from which its fronds are produced. These are erect, from one foot to two feet in height, twice divided, and narrowly oblong in outline, pale green in color, and agreeably fragrant, both in a fresh and dried state. It is found in various parts of England, but not everywhere.

The mountain buckler fern (Lastrea montana) is another of our indigenous plants which must not be overlooked. It has also a creeping root-stock, and the fronds vary from one foot to two feet in height by about six inches in breadth. They are lanceolate in outline, arching, and pale green. Its general aspect is that of the male shield fern (L. Filix-mas), from which, however, it is easily distinguished by its fragrance when shaken or rubbed. It is found mostly in our northern and western counties. It also occurs in Ireland, but is most plentiful in Scotland. Anemia tomentosa is a tropical American plant, and, as the annexed illustration shows, belongs to the section popularly known as flowering ferns. The whole of this family are handsome, dwarf-growing plants, requiring stove heat, but the fronds of this particular kind give off a strong odor of myrrh. Cheilanthes fragrans, one of the lip ferns, is a dwarf plant suitable for the greenhouse. It produces fronds about six inches in length by about an inch in breadth, deep green above, but paler below. These are delightfully fragrant—almost as sweet as violets. Lastrea fragrans is a small-growing hardy fern found in North America. It produces oblong-lanceolate fronds some nine inches long, and deep green, with a fragrance which some liken to that of May. Lindsæa cultrata is a fern common in Northern India, but not plentiful in cultivation. It is a dwarf plant with a slender creeping root-stock; fronds from six inches to one foot long, and about one inch broad. They are once divided into segments about half an inch or somewhat more long. They are what is termed dimidiate; that is to say, the whole leafy portion is developed upon the upper side of the mid-rib. They are pale green, and yield a powerful odor resembling that of sweet vernal grass, and which they retain a long time after being cut.

Sitolobium punctilobum. This hardy kind, the sweet-scented fern of the Americans, is very odoriferous when shaken or rubbed. Its fronds are about eighteen inches high, three times divided, the ultimate segments being small and vivid green in color. It is an elegant plant for the outdoor fernery, contrasting strikingly with our native kinds. Mohria thrurifraga is an elegant species from Natal, suitable for the greenhouse. Its fronds, which are erect, are from nine to eighteen inches long, and three times divided into small-toothed segments, which, however, become obtuse when fertile. The stem and mid-ribs are clothed

ANEMIA TOMENTOSA (FERTILE FROND, HALF NATURAL SIZE).

with reddish hairs. The fronds give off a strong aromatic odor, resembling that of benzoin. Asplenium fragrans is a West Indian plant, resembling somewhat the English black spleen-wort; its perfume resembles that of newly cut hay. Adiantum fragrantissimum may be likened to a long, narrow-fronded form of A. cuneatum. The fronds in a young state are slightly tinged with pink, and yield a perfume resembling that of cowslips or primroses. It is a most serviceable plant for cutting from, and to the bouquetist its scented fronds are a decided acquisition.—*The Garden.*

THE SEA SERPENT.

IT has been my belief for some years that there is some fitful gigantic wanderer inhabiting the ocean; but as I had never investigated the subject, or even read upon it, my impressions were vague and undefined. On the afternoon of August 12, 1886, about 1:15, I was engaged in the study of Professor Farlow's work upon algæ, when I heard the voice of Calvin W. Pool, town clerk of Rockport, at the door of my cottage at Pigeon Cove, saying: "There is some strange thing in the water. I think it is the sea serpent." I quickly took my station upon the rail of my piazza, so that my marine glass was about fifty feet above the water and but thirty-six feet from the shore. The creature was advancing in a northerly direction, and but little more than an eighth of a mile from me. I saw it approaching, passing, and departing, and watched it most attentively for about ten minutes. Judging by the apparent length of yachts whose dimensions I know, as they appear at that distance, I estimated the length to have been not less than eighty feet. The head seemed short, and about the size of a nail cask, while the middle of the body was larger than that of a large man. The color was dark brown, and it appeared to be somewhat mottled with a lighter shade. As the head was at no time raised above the water, I could not determine the color of the throat. The surface of the head and back was very smooth, and no one of the forty or more persons who saw it detected anything that looked like a fin or flipper.

Its movement was not that of a land serpent, but a vertical one, resembling that of the leech or the blood-suckers of my boyhood. I could distinctly see perhaps fifteen feet of the forward portion of the body, while back of that, the convolutions being greater, the depressions were below the surface, so as to present a series of ridges some ten or fifteen in number at a time. The extremity of the tail was not visible. During nearly the whole passage of a mile and a quarter either the muzzle or cranium cut the water so as to lead several to exclaim: "His head is white!" This fact would remove the possibility of its being anything floating with the tide. The cutting of the water was by something at least a foot wide, and caused wakes on either side. From my elevated position I could plainly see the movements of the body between them, while the rear portion caused another wake behind. Its course was a direct one, and its speed uniform and not more than five miles an hour. When it reached a point about a half-mile north of us, the undulatory movement seemed to cease, and the body was for a moment extended along the surface. There was then an apparent gathering of the caudal extremity into ridges nearer together than those previously seen, after which he disappeared. I judged that this latter movement was to aid in diving, but of course this is only conjecture.

On the 19th, a week later, the same creature, or one like it, appeared north of us, going in an easterly direction, and, although perhaps a half-mile away, it was distinctly seen by the Rev. David Brewer, assistant pastor of Park street church, Boston, by his wife and servant, and by several others. My attention was not called in season to permit me to observe anything of additional interest.

From a careful study, I am satisfied that the two localities most visited are the coasts of Norway and Cape Ann and vicinity, both rocky shores. [And both swarm with fish, this creature's food.] The limits of this article preclude any reference to the former, and but a bare mention can be made of the latter. I find the following well authenticated visits to these shores since the opening of the present century:

Gloucester	June 20, 1815
Gloucester	August 10–28, 1817
Gloucester	August —, 1818
Nahant	August 19, 1819
Swampscott	August 10, 1820
Nahant	July 12, 1823
Nahant	——, 1826
Lynn	July —, 1833
Swampscott	July —, 1849
Nahant	July 30, 1875
Gloucester	July 15, 1877

The reports concerning these have not come from ignorant and unreliable men, but from such gentlemen as Colonel Thomas H. Perkins of Boston; Chaplain Finch of the United States Navy; Samuel Cabot of Brookline; James Prince, United States Marshal; the Rev. Arthur Lawrence of Stockbridge; the Hon. Lonson Nash of Gloucester; and B. F. Newhall of Saugus; as well as from intelligent captains, sailors, and fishermen. I would gladly give the details of these reports, but can only say in this article that I am surprised to find such a substantial agreement between these statements and my own, as given in the *Boston Journal* and *The Cape Ann Breeze*. In length, in color, in movement, in size, in speed, as usually seen, and in the manner of cutting the water, our accounts so agree that I could give a complete account in the words of others written years since, and which I affirm I had never seen.

I am frequently asked: "If there be such a thing as a sea serpent, why is he not oftener seen?" I must frankly say: "I do not know;" and yet I can present some suggestions which satisfy my own mind. In the first place, large animals are not numerous. Eagles are less abundant than mosquitoes, elephants than mice, whales than mackerel. Again, Bishop Pontoppidan wrote, one hundred and thirty years ago: "This creature keeps himself at the bottom of the sea, excepting in the months of July and August, which is their spawning season." If this is true, as the dates just given would prove it to be, the time is short when it may be expected to appear. Again, the Bishop says: "They come to the surface in calm weather, but plunge into the water again as soon as the wind raises the least wave."

I reported the sea as a dead calm, and such has been the case almost always, I think. It has been so in every case but one which I have noticed, so that the conditions in this respect are not often favorable. Again, it may be that, like the great sea turtles, it is most active in the night, when it would be least observed. And again, we must remember that the ocean is vast, and that but an infinitesimal portion of its surface is at any time being scanned by the human eye.

I have now described the object which came under my observation. I shall not attempt to classify it. Whether it belongs to the mammalia, reptilia, or pisces, whether it be ophidian, cetacean, or saurian, I must leave it to the naturalist to determine. I am no stranger by the sea. A love for its beauty and grandeur, in calm and storm, as well as a fondness for the study of its teeming life, both animal and vegetable, minute as well as gigantic, has led me to spend eighteen summers upon its very verge. This experience makes me sure that no one who saw what I did would ever entertain the suggestion that it was a school of porpoises, a grampus, or a horse mackerel. Because some have been deceived by these, or a floating spar, or a mass of seaweed, it does not follow that others have not seen a genuine monster. Professor Silliman in his *Journal of Science* says: "We are ourselves not skeptical. We do not see how such evidence as was presented by Dr. Jacob Bigelow, in our second volume, can be set aside." Professor Agassiz informs us that "it would be in precise conformity with analogy that such an animal should exist in American seas. I see no chance to doubt that some huge animal with outward form much like a serpent did sometimes visit these shores."

Professor Richard A. Proctor writes: "Naturalists have been far less incredulous than the general public. We confess we do not well see how such a chain of probabilities can be readily set aside." Professor Gosse says: "Are not the facts sufficiently weighty to restrain us from rejecting so great an amount of testimony? I express my own confident persuasion that there exists some oceanic animal of immense size which has not yet been received into the category of scientific zoology." Professor J. G. Wood remarks that "it does require some courage to face the alternative of be-

ing either ridiculed as an ignorant fool or denounced as a contemptible impostor, but such is the ordeal through which all have to pass who venture to say that they have seen the sea serpent."

They are many grains of truth in this assertion, yet I have never regretted that I offered my report to the public; for I am confident that the time will come when its candid judgment will be assured of the existence of this denizen of the deep.—*Granville B. Putnam, in the Congregationalist.*

THE PROGRESS OF ASTRONOMICAL PHOTOGRAPHY.

IN the *Annuaire* for the present year, published by the Bureau des Longitudes, is an important article by Admiral Mouchez, the director of the Paris observatory. The article is really a history of the various applications of photography used by astronomers up to the present time, and the history is very well done. The article contains many details relative to the work which has recently been going on in the Paris observatory, which we think will be read with very general interest.

In the new instruments which the Brothers Henry have recently constructed at the observatory, before a plate is taken a telescope is pointed approximately to a bright star, which is examined with an ordinary eyepiece armed with a blue glass. In this way a slide can be placed very near the chemical focus, but in order to determine the focus exactly, an image of a star is made to run six or seven times along a very small plate at different marked distances inside and outside the focal point, as previously determined. An inspection by a magnifying glass of the different trails left by the star on the *cliche* shows which was the most exact chemical focus employed to produce them. This when once done really needs no repetition, but as a matter of fact the operation is repeated once a month.

Another point which the Brothers Henry have already settled is that in the case of very many photographic plates of extreme sensitiveness, the plates are practically useless unless they are prepared almost immediately before they are required, so that as a matter of fact very sensitive plates are now avoided.

Another limit to the sensitiveness, which can be utilized is the diffused light proceeding from the atmosphere, either from the gas of a large town, as in Paris, or from the presence of the moon. Very sensitive plates are liable to be fogged even by diffused light in the case of very long exposures.

We have before referred to the arrangements employed for enabling the images of stars to be differentiated from any accidental spots or dots on the plate. The plate is practically exposed three times to the region of the heavens, with such a small variation of position, however, that the three images of the star on the plate appear as one to an observer who looks at it casually, and a magnifying glass is really necessary to discover the triple nature of the image. This method of working has been found to have advantages which were not anticipated in the first instance. Thus, for the same total time of exposure the images of much more feeble stars are recorded with the three successive exposures than with one alone. This arises from the fact that the stars of the lower magnitudes, only being represented by very small points from one-thirtieth to one-fortieth of a millimeter in diameter, would escape all observation by the naked eye, and would not be visible at all on paper copies; while the three exposures give a larger image, visible to the naked eye, and perceptible on a paper positive. Moreover, if a small planet is included in the region being photographed, the deformation of the small triangle would instantly betray its presence, even with an exposure of a quarter of an hour. Admiral Mouchez has calculated that a planet at twice the distance of Neptune would be easily recognized in three successive exposures of an hour each—the motion of Neptune in half an hour quite destroying the triangle which it, like the stars, would make were it at rest.

The real and serious objection to the triple exposure is the wonderful patience and skill that are required to keep the instrument for three consecutive hours, without a moment's relapse, pointed rigorously toward the same spot in the sky. This is very trying work, and apt to overstrain those who perform it. Admiral Mouchez is alive to the fact that the way to obviate this difficulty is to increase the aperture of the object glass, and this is what probably will be done before very long.

Some very interesting information is given regarding the microscopical appearances of the images of the stars seen on the negatives: "The microscopical study of the *cliches* presents, moreover, much interest from many points of view, and the appearances of the images of the stars is so characteristic that it is impossible to confound them with accidental spots, as has been generally supposed. Were this point of view alone regarded, it would perhaps be useless to multiply the exposures of the same plate. The stars appear on the plate, in fact, not under the simple form of a round spot of uniform black tint diminishing and becoming clearer as the star gets smaller, but as a mass of small, round, black points, very close together toward the center for stars of the ten or twelve larger magnitudes, and more and more sprinkled, still retaining their blackness, for the fainter stars; and at the extreme limit beyond those stars which give a definite and certain image, there still appear on the *cliche* some small groups of little points scattered sparsely, but evidently recording still fainter stars, the existence of which can only be suspected without any means of further confirmation.

"Unfortunately, whatever progress we may make in optics or in photography, whatever penetrating and sensitive power we may hope to give to our instruments, it is evident that we shall never succeed in seeing the most distant stars, and that at whatever limit we may arrive, there will always be beyond it an infinity of others lost in the profundity of the heavens which will always escape our knowledge, but it is by photography and the scientific study of negatives that we shall be able to go further than by any other means. From a chemical point of view also the microscopical examination of the stellar images will not be without interest, because it will help us to understand how the light acts upon the molecules of the insoluble salts of silver which are contained in the stratum of organic material which forms the sensitized plate. It is not, as I have already stated, in giving a uniform tint, more or less decided, according to the magnitude of the star, over the whole image, but really in decomposing a greater or less number of particles of salts of silver over this area, that the light works; so that we can define the image of a very feeble star as a resolvable nebula, and the others as insolvable nebulæ surrounded by a resolvable portion. I have never seen around any of these images the rings referred to by several astronomers, which have the appearance of diffraction rings seen in telescopes.

"To establish the relationship between the scales of the optic and photographic magnitude of the stars, Bond has made a series of interesting experiments by varying the time of exposure and the aperture of the object glass. These experiments have led him to an interesting result on the mode of action of light. He has found that a certain time elapsed before the action manifested itself at all, and then that it did so suddenly. Ten or a dozen molecules of salts of silver in each superficial second of arc were attacked by the light; after this the number increased very rapidly according to the time of exposure. This mode of action seemed to him obscure and difficult to explain. But it seems to follow from these facts, and from the examination of our *cliches*, that in the manufacture of the bromide of silver, and the preparation of sensitive plates, it is of the highest importance to obtain the finest possible pulverization of the salt."

As there is to be a conference of astronomers at Paris next Easter to discuss the whole question of astronomical photography, it is well that Admiral Mouchez and his staff are accumulating so many facts to help in the discussion.—*Nature.*

HOW TO MAKE A SIMPLE DISSECTING MICROSCOPE.

TAKE an ordinary crayon box or a similar one having a sliding lid. To the back, attach a cork by means of a thin metal. Through this cork slide a rod on which slides another cork, or else have the rod of sufficient size to take the place of the cork. A piece of small stiff wire may have one end wound round the rod, while the other end projects at right angles to the rod, and this projecting end, sharpened and upturned, passes through holes in the handle of the magnifier. The lenses are focused by sliding the rod up or down and fastening by means of a small wooden wedge. The box may be divided into two parts by a partition, one part to be used as a drawer for keeping accessories, the other to be arranged as follows: Immediately beneath the lenses make an opening in top of the box. A piece of wood covered with white paper and placed below the object at an angle of about forty-five degrees answers for a reflector even better than a mirror.

The object rests on a glass slide over the opening in the top of the box. For a magnifier, procure a microscope consisting of three or four lenses, costing from seventy-five cents to one dollar and a quarter.

To make a mounting needle, take a fine sewing needle, and break off about one-third, so that it will not be too long and springy. Then with a pair of pincers force it into a handle, point first, withdraw the point, and finally force the needle in again with the point out. Sometimes it is well to make an opening in the handle with a sharp awl, and fasten the needle in place by pouring in melted sealing-wax. Old penstocks may be used for handles. If desired, the needle may be easily bent by heating it to redness in a flame. When bent, heat it red once more and plunge quickly into water to temper it. Rubbing on an oilstone may be necessary to remove roughness.—*N. Gleaner.*

STRENGTH OF THE COLD BENT, RIVETED STEEL PLATES IN THE SHEEPSHEAD BAY WATER TOWER.

THE SCIENTIFIC AMERICAN of December 25, 1886, contains a description of, and specification for, a 250 ft. steel plate water tower, and states: "The general conclusion appears to be that bad work in putting up the great pipe, and poor material, were the cause of its failure." This conclusion appears to me premature, for the following reasons: The strength of a cylinder or circular tower depends on its diameter, thickness, and the tensile strength of its sides, when finished ready for use. To build a cylinder out of riveted plates, the plates are first perforated with holes for rivets, then taken to rollers and bent to a desired curve, so as to form a circle when riveted together. It is known from experiments that, if two straight sheets of iron are riveted together and subjected to a straight pull, the joint will only bear about one-half that of the solid sheets. How much bent sheets, riveted together in the form of a cylinder, will bear to the square inch can only be known by a test, noting the amount of internal pressure required to rupture them. When steel plates are being bent by a system of rollers, they are subjected to a transverse strain, like a girder resting on two end supports and loaded in the middle. The force employed must be sufficient to overcome the resistance of the top of a plate to compression, or the bottom to tension, to the extent required for producing a permanent set of the plate to the desired curve. Now, the resistance of steel to compression is greater than its resistance to tension, consequently the under side of the plate will stretch more than the top compresses when bending. The effect on wrought iron plates is the reverse, on account of its resistance to compression being less than its resistance to tension. Cast iron plates submit to being bent only a small amount, on account of its great resistance to compression compared with its resistance to tension.

The effect of bending is more clearly seen when the bent plates are formed into a circular ring and subjected to internal pressure. The circular ring located in the tower 5 ft. 3 in. above the base was, according to the specification (page 405), 16 ft. outer diameter, ¾ in. thickness of sides, the length of its outer circumference, or surface, 603·185 in., and its inner surface 598·473 in., the difference 4·712 in. It is evident from this that before any tensile strain can be brought to bear on the inner surface of this ring, by internal pressure produced by partly filling the tower with water, the metal located ⅛ in. from the inner surface must be stretched ⅜ in., and that at ¼ in. from the same points 1·57 in.; that at ½ in. 3·141 in.; at ¾ in., or outer surface, 4·712 in. Under these conditions, assume the pressure increased until the inner surface is stretched 4·712 in. By this time the outer surface will be stretched nearly 9½ in., or the plate ruptured. Evidently the resistance of this ¾ in. ring to tension is overcome in detail, the outer surface rupturing first, and the rupture progressing inward as the outer surface gives, until there is no metal left to resist the unequal strain. The usual assumption that bent plates are not weakened by being bent cold is erroneous. From the test in this case, we find these bent riveted plates rupture from being subjected to the pressure due a column of water 2,661 in. high: $\frac{2{,}661}{27{\cdot}648} = 96{\cdot}2456$ lb. The diameter of ring 109·5 in. $\times$ 96·2456 = 18,334·78 lb. pressure on the diameter. From this it appears that the cold bent riveted steel plates in this ring ruptured when subjected to a tensile strain of 12,223·18 lb. per sq. in. According to this theory, the weak points in the tower were located 5 ft. 3 in. and 35 ft. 3 in. above its base. In practice the plates were found to give at those points. All things considered, it is probably true that these plates would not have ruptured when subjected to a tensile strain of less than 60,000 lb. per in. on leaving the manufactory; 15,000 lb. is the most per square inch of section that I should expect ⅜ in. riveted steel plates to bear, and about 10,000 lb. per square inch for 1½ in. situated as above. SAMUEL MARSDEN.

No. 1015 N. Leffenwell Ave., St. Louis, Mo.
January 15, 1887.

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