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LEO XIII.

On the 11th of September, 1870, General Cadoma, at the head of the Italian troops, passed the papal frontier. He found opposed to him a body of men under Generals Kauzier and Zappi. After a short engagement with the papal forces under Baron Charette, on the 20th of the same month, the invading army entered Rome, and the temporal power of the pope was extinguished.

Considering himself the head of the Roman Catholic church, and legal sovereign over the limited territory now captured, Pope Pius IX. never ceased to the last of his days to inveigh against the despoliation. For him to assent to the act and to accept the terms offered him by the Italian government was inconsistent with his duty, and was, indeed, beyond his power. It appeared a case of absolute *non possumus*. Presumably he considered that he had no more power to assent to the merging of the States of the Church into Italy than his predecessor, Pius VII., had to divorce Napoleon from Josephine. He always spoke of himself as a prisoner. On Feb. 7, 1878, he died, in the thirty-second year of his reign. He was the first pope whose years of occupancy of the papal chair have exceeded those of St. Peter.

Leo XIII. was his successor. His secular name and titles are Joachim Vincent Count Pecci. He was born at Carpineto, in the diocese of Agnani, on March 2, 1810. When eight years of age, he, with his brother, was placed in the Jesuit college of Viterbo. In 1824 his mother died and he went to Rome. Under the charge of his maternal uncle he entered the Roman college, which was also conducted by the Jesuits. His inclinations tended strongly to science. In 1828 the first prize in physics and chemistry was awarded him. This was in the first flush of the new science, when Faraday was a young man, and but three years before the death of Sir Humphry Davy. On graduating he began to study theology, and was intrusted, though so young, with the recitals in philosophy in the German college in Rome. He graduated as Doctor of Theology in 1831, and began the study of law at the University of Rome,

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and was graduated as doctor *in utroque jure.* On December 23, 1837, he was ordained priest. The fiftieth anniversary of his ordination has now been nearly reached. On his ordination he was appointed apostolic protonotary for the provinces of Benevento, Spoleto, and Perouse. On January 27, 1843, he was ordained archbishop. He was not assigned to full possession of an ordinary see, but was made titular archbishop of Damietta *in partibus* and was sent as envoy to Brussels. This position he filled for three years, dwelling in the different cities of Belgium, and when he returned to Rome he received the grand cord of the order of St. Leopold.

On Jan. 19, 1846, he was appointed archbishop of Perouse, thus at last receiving a regular see. On July 21 of that year he took possession, and for thirty-two years held that position. On Dec. 19, 1850, he was created cardinal of the order of priests.

His administration of his province included the civil as well as ecclesiastical order. In the former he displayed much ability. He put an end to brigandage, which had formerly been common, and so effectually repressed crime that at one period the prisons were all empty. Considerable popularity was thus acquired by him, and some indications of the power he has since displayed as a diplomat may be traced in the work of those days.

At the consistory of the cardinals held Sept. 21, 1877, Cardinal Pecci was elected chamberlain of the Catholic church. On the death of Pius IX. the conclave of cardinals had to be organized by him. This conclave was held in February, 1878. After a sitting of thirty-six hours' duration he was elected pope, upon the third ballot. This was on Feb. 20, 1878. He took the name of Leo, and was the thirteenth pope who assumed it.

Leo XIII. entered upon his pontificate in most difficult times. Deprived of temporal power and little better than a dweller in Rome, he found himself, like his predecessor, unable to accept the conditions of settlement offered by the Italian government. Ceaselessly protesting against his state of imprisonment in the Vatican, his untiring energy, backed by his diplomatic ability and accomplishments, made him take full cognizance of the tendencies of modern politics and society. The nihilists and socialists of Russia and Germany received his attention. In his early encyclical of Dec. 28, 1878, the intellectual forces of catholicism are appealed to against them.

Prussia at this time was in a state of religious ferment. The laws affecting Catholics and all religious instruction, named, from their advocate and introducer, the Falk laws, and also called the laws of May, were and had been for some time in full force. Under them priests and bishops had been imprisoned for administering their charges in accordance with their ideas of duty. Though far less in severity, they resembled in kind the penal statutes formerly in vogue in Ireland. The Falk laws, however, were severe enough to cause the imprisonment of many ecclesiastics, simply for exercising their spiritual functions without authorization from the government.

Pius IX. never ceased his protests against the course of the German government. He was inflexible in his opposition. Leo XIII. was equally so. The German authorities gradually found that they had a severe task on their hands in attempting to enforce the obnoxious enactments. Leo XIII. signalized the beginning of his reign by opening communication with Germany on this subject, and with Russia on behalf of the Polish Catholics, who, like their co-religionists in Germany, were suffering penalties for the faith. For several years the German troubles continued. In 1879 only three Catholic sees in Germany had bishops, the rest were rendered vacant by death or exile, and thousands of parishes had no priest or public worship. One ecclesiastic, Dr. Foerster, Prince-Bishop of Breslau, had died in exile. In the see of Treves one hundred and fifty-three parishes were vacant. For this see the assent of the German authorities to the appointment of Dr. Korum as bishop was obtained. A mission to Rome was intrusted to Dr. Schloezer, and diplomatic relations were ultimately re-established.

While thus inaugurating the difficult task of reconciliation with Germany, and beginning to prove himself a diplomat of the highest order, the pope showed no less firmness than his predecessor in the assertion of his rights and in condemnation of the acts of the Italian government. He constantly claimed that he was a prisoner. On July 12, 1879, the body of Pius IX. was removed from its temporary resting place to a tomb prepared for it in the church of St. Lorenzo *extra muros.* The procession was attacked by a mob, the police protection was insufficient, and many were injured, and it was with difficulty that the church was reached. Two days later the pope vehemently protested against the outrage, which had one good feature in proving that his claims that he was not safe from assault in Rome were well founded.

At the inaugurating of his reign he had avowed himself a Thomist or theologian of the school of St. Thomas Aquinas, the Angelic Doctor, as he has been termed by the disciples of his philosophy. He did all in his power to encourage the study of his philosophy and theology at Rome, and inaugurated the publication of a new and complete edition of his works. In his early encyclicals the subject of marriage and divorce and of Catholic education were luminously treated of. His views on these subjects, together with his action with regard to St. Thomas' works, show the bent of his mind to be toward the soundest and most conservative views. At the same time his attention to all events of the day, and his treatment of the Prussian question, show a mind fully as advanced in the direction of events of the day.

In 1882 an encyclical was issued, calling upon the Catholics throughout the world to form religious societies, and to devote themselves to the re-establishment of the papal liberty of person. In February of this year the Prussian ambassador, Baron Von Schloezer, already alluded to, arrived at Rome. Russia, France, Brazil, and other South American states and England, prepared to enter into diplomatic relations with the Roman see. The achievement of all this in so few years testifies to Leo XIII.'s wonderful executive and administrative talents. While foreign affairs were thus made to take on a more favorable complexion, by several occurrences the relations of the Italian government to the pope were placed on a more unfavorable basis than ever before. The carriage of Count Paar, the Austrian ambassador to the pope, was attacked. The assailant was arrested and tried, but in pronouncing judgment the diplomatic character of Count Paar was completely ignored. The Italian government awarded less consideration to the status of the pope than did all the leading powers of the world.

The Russian government in this year restored to the Roman Catholics of its territory more of their liberty than they had enjoyed for a very long period. A convention embodying these grants was entered into between the pope and the Russian government. The trouble with Germany as yet, however, was only partially palliated. While thus occupied with the Christian powers, princes quite out of the Christian pale were accorded full consideration. In consequence of the good feeling the Sultan of Zanzibar had shown toward Catholic missionaries, the pope presented him with an elegant mosaic.

The year 1883 was signalized by the seizure by the Italian government of the property of the Congregation de Propaganda Fide. This placed a still greater barrier between any reconciliation with this power. But in Germany matters began to improve. A Catholic relief act was passed which did away with some of the severities of the laws of May. The further exercise of their powers and functions by bishops and priests was legalized. The affairs of Ireland also were in this year considered in a brief addressed to Cardinal McCabe, Archbishop of Dublin, in which the faithful are exhorted not to follow the lead of agitators who condone assassination and crime.

The further confiscation in 1884 by the Italian government of property belonging to the Propaganda caused the pope to decide to establish stations in other countries where the offerings of Catholics throughout the world might be more safely stored and invested. As an offset to the troubles with Italy, a steady amelioration of relations was in progress in Germany.

The position of the pope as arbiter in national matters was exemplified in 1885 in a dispute between Spain and Germany as to their rights in the Caroline Islands. A very serious dispute was impending between these powers, upon the subject of the occupation by Germany of certain islands of the group. Eventually the Emperor William and King Alfonso agreed to submit the matter to arbitration, Pope Leo XIII. being selected as arbiter. In the present conjunction of affairs, it was a matter of much interest to see the pope occupying this station, and as arbiter, nominally, at least, preventing war and affording a peaceful solution of international disputes. This affair also indicated the friendly relations of the pope with Germany, and in 1886 the remarkable action of the pope in the matter of the septennate still more definitely proved the reality of the great achievement of reconciliation with Germany. The pope advised Catholics to vote for the upholders of the septennate bill in the Reichstag, and Bismarck in return still further abrogated the Falk laws.

This ends our consideration of the leading events of the life of this remarkable man. His mode of dealing with questions that have come before him has already earned for him a title. He is termed Leo the Pacific. Rapidly approaching his eightieth year, and of delicate bodily organization, little more could be expected from him were it not for his past actions. But from what he has already done in his short pontificate, much may be augured for the future. The work in Germany is done, and perhaps even in Russia, but France and Italy are still recreant. Before the death of Leo a reconciliation may be effected with these two powers.

Recently it is known that earnest efforts have been made to improve the relations between Italy and the papacy. In a late allocution of the pope they are alluded to, and, in his own words, "the means of obtaining concord would be to establish the pope in a position where he would be subject to no power in the enjoyment of full and real liberty."

In 1871, at the period of the deposition of the pope, an annual income of $645,000 was voted him. This money Pius IX. and Leo XIII. both have refused to touch. It now amounts to over ten millions of dollars. In the restoration of the rights claimed, this sum might also be accepted as a consequence of the agreement. At any rate, there seems to be the sound of a reconciliation in the air. The pope, as spiritual head of so many millions of subjects, should possess a sovereignty analogous in some sort to that exercised by the Federal government of this country over the District of Columbia.

In the lineaments and strong profile of the portrait it is easy to recognize the power of the man. Occupying so critical a position at what in history will always be pronounced one of the darkest epochs of the papacy, he has, by a rare combination of firmness and tact, won for himself a title to lasting renown.

JEAN BAPTISTE BOUSSINGAULT.

JEAN BAPTISTE BOUSSINGAULT.

Jean Baptiste Boussingault, who has just died,* in his 86th year, was certainly one of the grandest scientific figures of our epoch. His labors have rendered his name imperishable; and it is fitting that we should sum up in some detail the history of the life of this great chemist, and of that long career of his, which was so well occupied with ceaseless labor and replete with startling discoveries.

Boussingault was born at Paris, on the 2d of February, 1802. After finishing his classical studies he was admitted at the St. Etienne School of Mines, which he subsequently left with the diploma of engineer. The young scientist, who had a very active mind, and who was strong and energetic, eagerly accepted an offer that was made to him by an English company to go to South America in order to look up old mines that had been filled in for years, and, after opening them, to superintend their exploitation. He started at the age of twenty years, and the sojourn that he made in a foreign land was much more prolonged than he could have thought that it would be on leaving his native country. In South America he made the acquaintance of Humboldt, who took him into his friendship. He traveled through Bolivia and the province of Venezuela, and visited the then almost unknown regions which extend between Carthagena and the mouth of the Orinoco. Finally, at the time of the general insurrection of the Spanish colonies, the young engineer, desirous of associating himself in the conquest of the people's independence, became attached to the staff of Bolivar, with the rank of lieutenant-colonel.

For six consecutive years, Boussingault remained in these wonderful regions, where nature is so rich and exuberant, and never ceased occupying himself with study and the results to be drawn therefrom. The store of information that he gathered was immense, and during the entire length of his existence he took pleasure to the last in recalling the episodes of his stay in America.

He made innumerable mineralogical analyses in Bolivia and the neighboring countries, and he discovered a new mineral, a hydrocarbonate of lime and soda, that he called gay-lussite. Despite the difficulties of travel, he managed to find means of gathering information. Sometimes he made his analyses of minerals on horseback, through the aid of an assay balance that he carried with him. He had a Fortin barometer strapped over his shoulder, to which he was as much attached as to a faithful companion, and which he used for determining altitudes. His methods of investigation were often wonderfully ingenious. Let us take, for example, his researches upon the temperature of volcanoes at the time of his great excursion to the volcanoes of Ecuador. Arriving one day at the very mouth of the volcano Pasto, he became desirous of finding out what the temperature was at the bottom of a gulf from whence burning vapors were escaping. On placing an ordinary mercurial thermometer in the vapor the mercury was observed to shoot up to 102°, and the instrument would have been broken had it remained therein for a few minutes.

The young engineer then conceived the idea of lowering some tinfoil that served as a wrapper for chocolate. The heat melted the foil, and this showed that the temperature was higher than that at which tin melts, say 235°. After this he lowered a lead pistol ball, which came up intact without having been softened. The temperature was, therefore, less than that at which lead melts, say 332°, and was comprised between the two extreme limits. This visit to the volcano Pasto was not free from peril. The guide who accompanied our traveler could not conceal his apprehension on hearing the subterranean roaring, and on beholding the crater. "Should it spit," said he to the engineer, "we would be lost," replied Boussingault. "That is just what I think," replied the guide, with perfect calmness.

Boussingault was never exhausted of anecdotes when he reverted to the souvenirs of his adventurous youthful existence. We shall cite some of them. During his travels in the pampas, he was accompanied by an Indian, who sometimes cared for him as if he were a child. Being attacked with a fever that came near taking him off, his Indian, with a quasi-maternal solicitude, saved him by chewing some properly selected aliments, that he introduced into his patient's mouth. It was in the midst of the pampas that Boussingault made his researches upon curare and certain other poisonous substances, and it was there that he studied the properties of coca. He stated in his lectures that he had often seen Indians travel to great distances without taking any food for twenty-four hours, and this they were enabled to do through chewing coca leaves, which they carried in little bags.

The agriculturist showed beneath the chemist while Boussingault was making his explorations in America. "He did not cross a plain," says Mr. E. Tisserand, one of his biographers, "did not cross a mountain or river, did not meet with a useful plant, without making researches and observations that might give instruction as to the mysteries of that nature which is so different from our own. Thus, in 1822, we find him studying the tree which, in the Cordilleras of Venezuela, furnishes a sap that, in appearance and taste, resembles cow's milk. Boussingault analyzed this product, and found therein the elements of common milk, with the difference, however, that the fatty matter is replaced in it by a wax analogous to that made by bees."

After this, the products extracted from plants by the Indians for the most varied uses, either for nourishing man or for killing him, were what attracted his attention, and what were later on to afford material for learned papers on chica, hura, rocou, vegetable varnish, and the banana. These works are still to be read with as much interest as profit.

Boussingault took part with Bolivar in several battles, and was one of his most devoted officers. During the pillage of a certain city, he had in charge the protection of a convent, in which he stayed for some time.

He was a witness of some earthquakes, and one day was obliged, in order to save them, to drag some unfor-

* May 11, 1887.

tunates by the feet who were prostrate before a church and were about being crushed by the toppling edifice.

Our traveler returned to France in 1833, where he was soon appointed professor of chemistry at the Lyons Faculty of Sciences, of which he shortly afterward became the dean. In 1839, after making himself remarked by important researches, he was called to the Academy of Sciences, and came to Paris, where he was appointed professor at the Conservatory of Arts and Trades. In 1848, he represented the department of the Lower Rhine in the Constituent Assembly. Here he took his place among the moderate republicans.

Through election, he became a member of the State Council. On the 2d December, he left the latter and renounced a political life forever.

After that he devoted himself exclusively to science. In 1876, he was promted to be grand officer of the Legion of Honor.

After Mr. Chevreul, Boussingault was the oldest member of the Institute. He belonged to the section of rural economy, where, nearly fifty years ago, he succeeded Huzard, once inspector of veterinary schools.

The works of Boussingault occupy a wide space in the history of chemistry. In concert with J. B. Dumas, he performed those memorable experiments on the composition of the air that in a measure crowned the edifice erected by Lavoisier, and that have become classic.

It was starting from 1836, a short time after his return to France, that Boussingault began to devote himself to the study of his choice—that of vegetable physiology. The results that are due to him in zootechnics concerning the food of animals, and in agriculture concerning the nutrition of plants, are of the highest importance. In 1838 appeared the magistral work of the great agriculturist—the result of his chemical researches upon vegetation. Balance in hand, Boussingault verified the fact, partially seen by his predecessors, of the fixation, by plants, of the carbon contained in the carbonic acid of the atmosphere. He definitely proved at the same time that plants decompose water in order to appropriate its hydrogen. Finally, he demonstrated that cereals exhaust the soil of nitrogen, and that, according to the expression of Lavoisier, "Nothing is created, nothing lost," either in the vegetable kingdom or the laboratory. What is put into the soil as a fertilizer is found again in the plant.

An indefatigable investigator, an analyst of consummate skill, Boussingault for many years proceeded on his farm at Bechelbronn, in Alsace, with a series of analyses of plants and fertilizers, and the results of these have been followed by the creation of a theory of agriculture.

Under the direction of our chemist, the Bechelbronn farm was an experimental one, and never could have been one of profit, since Boussingault, always having the interests of science in view, neglected the financial side of its exploitation.

After his farm, his laboratory at the Conservatory was for many years his favorite center of work. Toward the end of his career, he paid much attention to metallurgy. His analyses of specimens of iron and steel have rendered signal services to one of the chief branches of the applications of chemistry.

The eminent professor stopped lecturing at the Conservatory in 1873, and was succeeded by Prof. Schloesing.

The tenderness and care of his son Joseph and of his two daughters made his old age calm and peaceful, but, before rendering the last sigh, the master was obliged to undergo a painful sickness.

The number of Boussingault's works and memoirs is so extensive that we could not think of enumerating them, even succinctly. Many of his memoirs are to be found in the *Comptes Rendus* of the Academy and the *Annales de Physique et de Chimie*, of which he was one of the editors.

"Like all masters of science," says Mr. Tisserand, "Mr. Boussingault was not content to do work in his laboratory and on his farm, but sought to propagate new doctrines and popularize his methods.

"His treatise on rural economy is a classical work that may be considered as one of the first monuments of French agriculture. Finally, his lessons at the Conservatory of Arts and Trades have formed a nursery of young scientists, who, inspired with his ideas, are continuing his work to the great advantage of agriculture. Upon the whole, it may be said that the influence of Boussingault's publications and labors upon agriculture has been immense. His works have been the true starting point of the great agricultural movement that has occurred within the last forty years. It was the Bechelbronn farm that led to the foundation of Rothamstead, in England, and that served as a model to the Germans for the creation of those laboratories for agricultural research of which they are so proud; and it may be loudly proclaimed that none of these establishments has as yet produced as much and made so important discoveries as Bechelbronn."

Alas! we have lost the Alsatian land of Bechelbronn; but there is one thing that will always remain to us, and that is the luster that the labors of Boussingault shed over it. Nothing can rob us of the glory of that, and these labors, in spite of all, will continue to shine through ages.

Boussingault, by the accuracy of his method and his perspicacity, is worthy of being placed alongside of J. B. Dumas as another continuer of Lavoisier. He merits the appellation of Father of Rural Economy and the Creator of Agriculture. His name is forever written among those of the great men of our age.—*La Nature.*

THE AIR OF THE SEA.

THE air of the sea, taken at a great distance from land, or even on the shore and in ports when the wind blows from the open, is in an almost perfect state of purity. Near continents the land winds drive before them an atmosphere always impure, but at 100 kilometers from the coasts this impurity has disappeared. The sea rapidly purifies the pestilential atmosphere of continents; hence every expanse of water of a certain breadth becomes an absolute obstacle to the propagation of epidemics. Marine atmospheres driven upon land purify sensibly the air of the regions which they traverse; this purification can be recognized as far as Paris. The sea is the tomb of moulds and of aerial schizophytes.—*MM. Moreau and Miquel.*

THE SEVERN AND MERSEY TUNNELS.

WE have already, on several occasions, called the attention of our readers to the large estuaries that cut to so great a depth into the coasts of Great Britain, and that have had so great an influence upon the maritime history of the English people. This peculiar arrangement of the coast has likewise exerted a great influence upon the art of the engineer, since it has presented so many obstacles to the passage of the railways that connect the large commercial and industrial cities built upon the banks of these waters. It is thus that, with the beginning of metallic structures, we find those—Chepstow, Britannia, and other bridges—which mark an epoch in history, and, later on, those great viaducts thrown across the sea, like that of the Firth of Tay, which met with so sad a catastrophe on the 28th of December, 1879.

In addition to bridges and viaducts, recourse has been had to tunnels, also, for crossing these great estuaries, and every one knows, for example, the bold work that descends under the Thames to London, and which was constructed with so much courage and perseverance between 1824 and 1842 by the French engineer Brunel. This tunnel, which is 1,300 feet in length, has a double gallery for pedestrians and vehicles, and is now used by the East London Railway Company.

Another tunnel, an iron tube one, designed for pedestrians only, is due to the Messrs. Barlow. This structure, which puts the tower of London in communication with Wine Street, is 1,318 feet in length and 6¾ feet in diameter.

We might cite in America, too, the tunnel projected under the Hudson, at New York, and the one at Detroit, which now seem to have been abandoned, although work on them had been begun. Must we add to these, too, the Channel tunnel, which is condemned to wait until the opinion of the English public decides to extend a mode of communication with a foreign country that it so highly appreciates at home?

Two large tunnels established at the mouth of rivers or estuaries of the English coast were opened to travel in 1886. These were the Severn tunnel, which puts the city of Bristol in direct communication with Aberdare in Wales, and the Mersey tunnel, which runs from Liverpool to Birkenhead.

The Severn tunnel, which is the larger of the two, is, including the lines of approach, 5½ miles in length, and that of the tunnel properly so called is $4\frac{3}{10}$ miles, about half of which is situated under the Severn. It is provided with a double track line supported on sleepers, and is traversed in ten minutes by the regular trains. The direction line is situated wholly in a horizontal plane, and includes, at the extremities, two sloping portions that are connected with the external roads by curves of great radius, and which run under the Severn with an inclination of about one tenth of an inch to the foot, and which are connected near the center of the work by a horizontal track 984 feet in length. The minimum height between the bed of the river and the extrados of the tunnel is 30 feet. The depth of the Severn at low water is 55 feet, and at high water 91 feet—a difference, as may be seen, of 36 feet.

The tunnel is faced with Staffordshire vitrified bricks, laid with cement. The width is 25 feet, and the height, at the key, is 24½ feet.

Ventilation is secured by means of a Guibal apparatus, 40 feet in diameter, that discharges 240,350 cubic feet of air per minute.

This gigantic enterprise necessitated twelve and a half years of work, which was carried on amid innumerable difficulties, resulting especially from infiltrations of water, which twice filled the work.

The construction was authorized in 1872, after plans of Engineer Charles Richardson (a pupil of Brunel), who pursued the work in concert with Sir John Hawkshaw as consulting engineer. It was carried on by the Great Western Railway Company until 1879, when a great influx of water in twenty-four hours completely submerged the parts already excavated. It was a very troublesome matter to pump out the works, and the water was not mastered until February, 1881. After this the work was carried on with the greatest vigor by Contractor Walker, who employed upon it no less than 4,000 men, and, in the month of September, communication had already been established from one end of the tunnel to the other. The section where the leak occurred, however, was provisionally left aside, and when, in 1883, work came to be resumed upon it, another leak was met at about 73 yards from it, which again quickly inundated the work and drowned three of the seven men who were at work at the spot. It became necessary to pump out the entire tunnel situated under the river, and this operation was accomplished before the end of the same year, thanks to the energy with which the work was pushed forward. After this, the widening out was resumed without further incident.

The amount of material excavated was 18,700,000 cubic feet. A length of 5,248 feet was excavated through Pennant freestone and the coal measures, 2,600 through the conglomerate situated above, and 2,600 through the schistose clay of the coal beds and the red marl of the new lower red sandstone.

The perforator used up to 1877 was Mackean's. This was replaced at that epoch by Geach's, and later on by Darlington's. The advance made by using two apparatus at once varied between 6¾ and 9 feet a day.

The tunnel under the Mersey, shown in section in Fig. 2, runs from Liverpool to Birkenhead, and establishes a connection between six different railroads. Its total length is 23,615 feet, 6,165 feet of which are between the river wharfs. Its width is 26 feet, and its height, to the key and above the rails, is 18¾. The line is a double track one.

The lining consists of six or eight rings of brick laid in Portland cement. As the rock was new red sandstone permeable to water, it became necessary to multiply precautions for obtaining a very impervious lining, and, for the internal rings, recourse was had to Staffordshire hard blue bricks. The tunnel is situated 33 feet beneath the river bed, and, like that of the Severn, has in the direction line two long sloping portions connected under the river by a horizontal stretch about 1,300 feet in length. The mean inclination of the gradients is about three tenths of an inch to the foot.

Ventilation is secured by four Guibal apparatus placed, as shown in Fig. 1, at the mouth of a shallow well connected with the tunnel through small sloping galleries 7¼ feet in diameter. Knowing how insufficient the ventilation of the underground railway of London is, an endeavor has been made to secure a complete renewal of the air in the Mersey tunnel. The

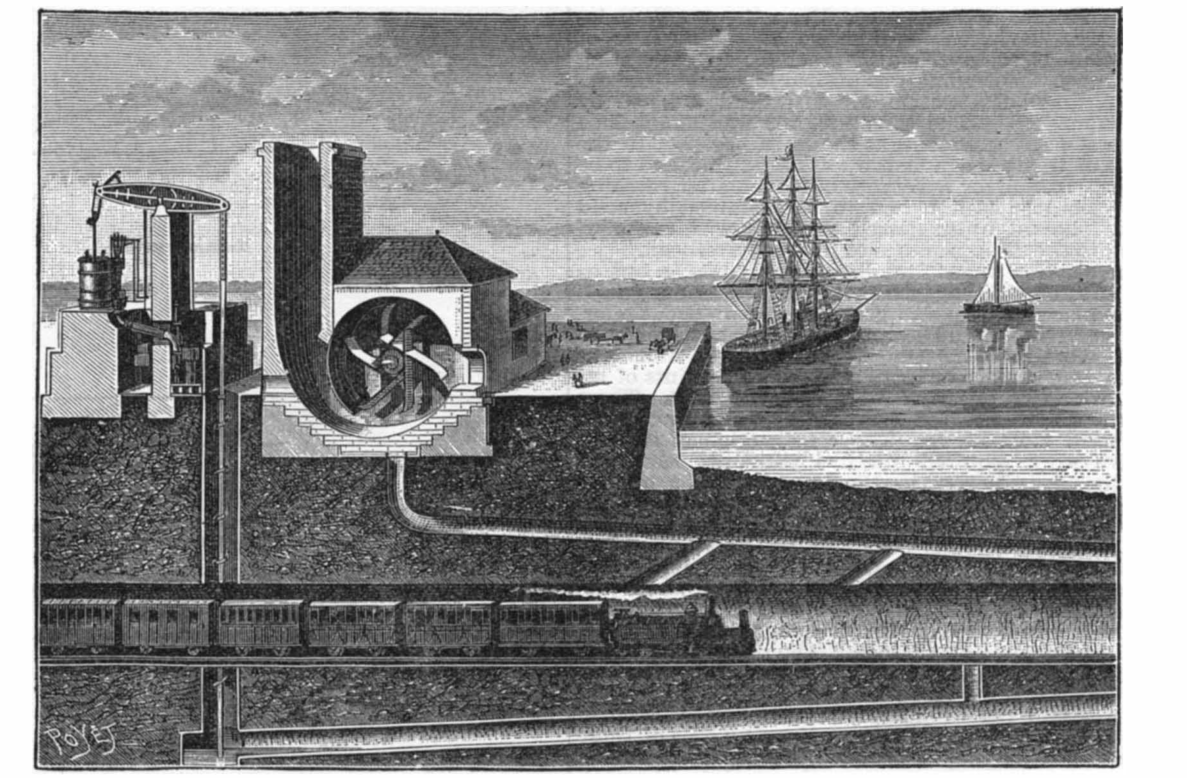


FIG. 1.—SECTION OF THE ENTRANCE TO THE MERSEY TUNNEL.

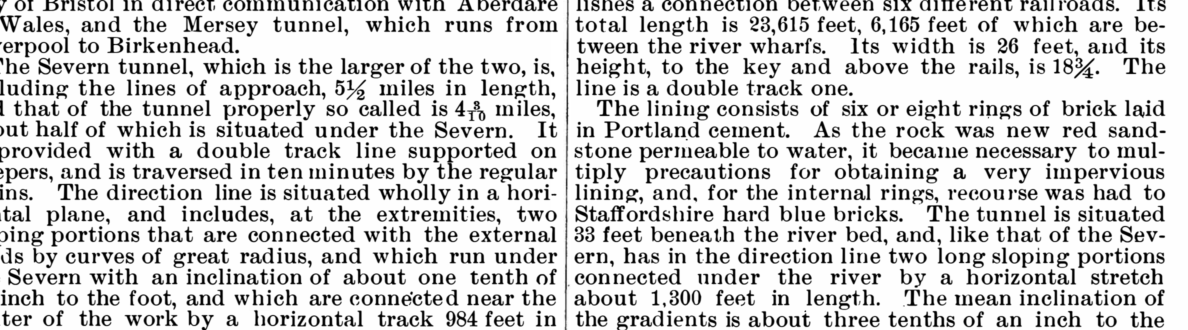


FIG. 2.—SECTION OF THE MERSEY TUNNEL.

exhaustion is effected by means of special pumps set up in two wells 17 feet deep, situated on the two banks. These wells, which are 5,310 feet apart, are connected at the bottom by a gallery 7 feet in diameter, forming a drain at the level between inclines to collect the water that enters from behind the masonry lining. This water is led to cisterns of a capacity of 92,400 gallons, located at the bottom of the wells, and forming a reservoir in case of a sudden influx of water.

The pumping apparatus used on the work included five pumps at the Liverpool shaft and six at the Birkenhead, actuated by three compound engines. They were capable of removing 22,440 gallons per minute when running normally, and thus gave every guarantee of security, since the influxes did not exceed 9,240 gallons. The construction of this tunnel was carried on with extreme care, and an endeavor has been made to secure all the conditions of hygiene desirable, so that the railroad can compete without too much disadvantage with the steam ferry boats plying upon the river; and, in this, complete success has been obtained, for in a communication on this subject to the English Society of Engineers, Mr. Fox, one of the constructing engineers, says that on the day of the inauguration, at which the Prince of Wales was present, thousands of persons traversed the tunnel without getting a drop of water on them. The determination of the direction line was effected with minute precautions, which, moreover, were indispensable for obtaining some precision, since the presence of large buildings on the wharves did not permit of recourse being had to direct datum points. The lines were obtained by suspending in the shafts taut silver wires, 0·02 inch in diameter, that were passed through the pump pieces, and the freedom of which from contact was ascertained electrically. Thanks to such precautions, there was an insignificant deviation in direction at the meeting of the headings of less than 2¾ inches. In excavating the tunnel, the heading was pushed forward at the upper part, and the section was afterward widened by known methods. The direction line was maintained in the new red sandstone, as shown in Fig. 2. In the center of the tunnel a fissure was found that had to be stopped up, and for a distance of 19 feet, after reaching 10,330 feet, the section had to be sustained by solid wood, followed by an immediate lining with masonry, owing to the disappearance of the rock overhead.

The blasting was at first done with dynamite, but, as this substance disengaged too much deleterious gas, it was replaced by Nobel's gelatine. Afterward, preference was given to gun cotton, the effects of which were much more regular. Outside of the river, numerous shafts were sunk in order to multiply the points of attack, which at one time were as many as 24. These shafts, which likewise served for ventilating, were afterward stopped up. The construction of this extensive work required but five years, say less than half the time absorbed by the Severn tunnel; but the distance under the Mersey was much less, and the work was not interfered with by so grave accidents. The work, which was begun in 1881, was preceded, however, by nearly two years of study and preliminary borings, in which $500,000 were spent, and which demonstrated the possibility of executing it. The borings were made with the Hawkshaw apparatus, under the direction of Major Isaacs. The plans were got up by Mr. Jas. Brunlees and Sir Douglas Fox, who likewise supervised the execution of the work. The total cost was $425 per running foot. As may be seen in Fig. 2, the line includes four stations. Three of these are situated on the Birkenhead side, and are as follows: Green Lane, the starting point; Borough Road, where are stationed the depot for the rolling stock, the gasometers for supplying the cars with illuminating gas, and the repair shops; and Hamilton Square, where the tracks are 100 feet below the ticket office on the level of the street.

On the Liverpool side we find the James Street station, which is situated 91⅛ feet below the level of the earth.

The interior arrangement of these two last named stations is very interesting, for we find therein an example of the difficulties of all kinds that accompany the operating of a subterranean railroad, and of the costly installations that it is necessary to have recourse to in order that the access shall not be too inconvenient and disagreeable to the public. These two stations are each 400 feet in length and 50 in width, and are connected with the ticket office at the street level by three different means, viz., by a stairway of more than 160 steps, by a subterranean inclined plane, and by three independent elevators.

These latter, which form the characteristic feature of the stations, are actuated by a hydraulic pressure of 770 pounds to the square inch, obtained by forcing water, by means of pumps, into an 11,880 gallon reservoir, located in a tower overhead. The car is capable of holding 100 persons at once. It takes 45 seconds to make the descent. The piston is of soft steel, of tubular form, and is 18 inches in diameter. It is made up of sections assembled by internal rings. The stroke is 76 feet at James Street and 87 at Hamilton Street. The cylinder is a cast iron tube 1¾ feet in diameter and 1 inch in thickness.

Each elevator well descends to a depth of 8 feet beneath the earth of the lower platform and rises to a height of 10 feet above the vestibule. These wells have a rectangular section of 21×19 feet. One portion, which is formed in the solid rock, has no lining, while the rest consists of brick and cement walls. On each side is built up a wall consisting of four rows of spruce blocks, which supports eight rows of rails affixed by screws. Four of these serve to guide the car, and the other four the counterpoises. The car is guided from top to bottom by four V-shaped pieces, 15¾ inches in length, that embrace the head of the rail, and is supported by a St. Andrew's cross, which connects it with the piston, and which may be regarded as a remarkable specimen of forged steel pieces of complicated form. The bar from which it was made weighed 3½ tons, and the weight of the piece itself is 2,860 pounds. The car forms a handsomely decorated chamber 19½ feet in length, 16½ feet in width, and 10 in height. The roof is of teak, and the floor timbers are of pitch pine, special experiments having shown that the latter has a greater resistance than other woods have.

The empty car of each elevator is balanced by a 7,590 pound weight, which is connected with it by chains running over pulleys at the top of the well. The chain is so arranged that 39 additional weights of 88 pounds each may be added or removed, according to the weight of the car. The motion of the latter is controlled by a bronze valve located at the bottom of the well, and which is so constructed that it can be opened gradually and without shock. This valve is maneuvered by a rope in the usual manner.

The force pumps that supply the reservoir are double acting ones, and comprise two steam cylinders 11 inches in diameter. The stroke of the pistons is 20 inches. There are three of these pumps at the James Street station and two at the Hamilton Street one. The necessary steam at each station is furnished by three return flame boilers, six feet in diameter and eleven feet in length.—*La Nature.*

[RAILROAD GAZETTE.]

AUTOMATIC SIGNALS ON THE BOSTON AND ALBANY RAILWAY.

THIS road has had a larger experience with electric signals than almost any other in the country. A large portion of the road is now equipped with such signals, and additions to the plant are constantly being made. A brief description of the apparatus employed will be followed by some account of its practical working and the results obtained.

The road has double track throughout its whole length, except the first ten miles, where there are four tracks. This short distance and some other detached portions of the road have continuous overlapping blocks; the remaining applications (with a single exception) are "station blocks" so called; that is, there is a signal each side of the station about one-half mile distant, which is connected with every switch in the track to which the signal belongs, and the function of which is to protect a train while standing at a station or switching. As traffic increases, or for other reasons it becomes advisable so to do, these applications can be made parts of a system of continuous blocks, with no other change than simply overlapping the sections.

For the first mile from Boston all trains are of the same class and run on the same tracks. After that they diverge, express passenger and freight trains running westward on track No. 1 and eastward on track No. 2; while suburban passenger trains travel westward on track No. 3 and eastward on No. 4 for 10 miles, to the end of the four-track section. A large part of the suburban trains go no farther, and beyond this point all trains again run on two tracks.

In the first mile the signals are about ¼ mile apart, then ½ mile for two miles more (which includes a large yard for outgoing and another for incoming freight trains, besides two important junctions), and then about a mile apart as far as the continuous blocks extend.

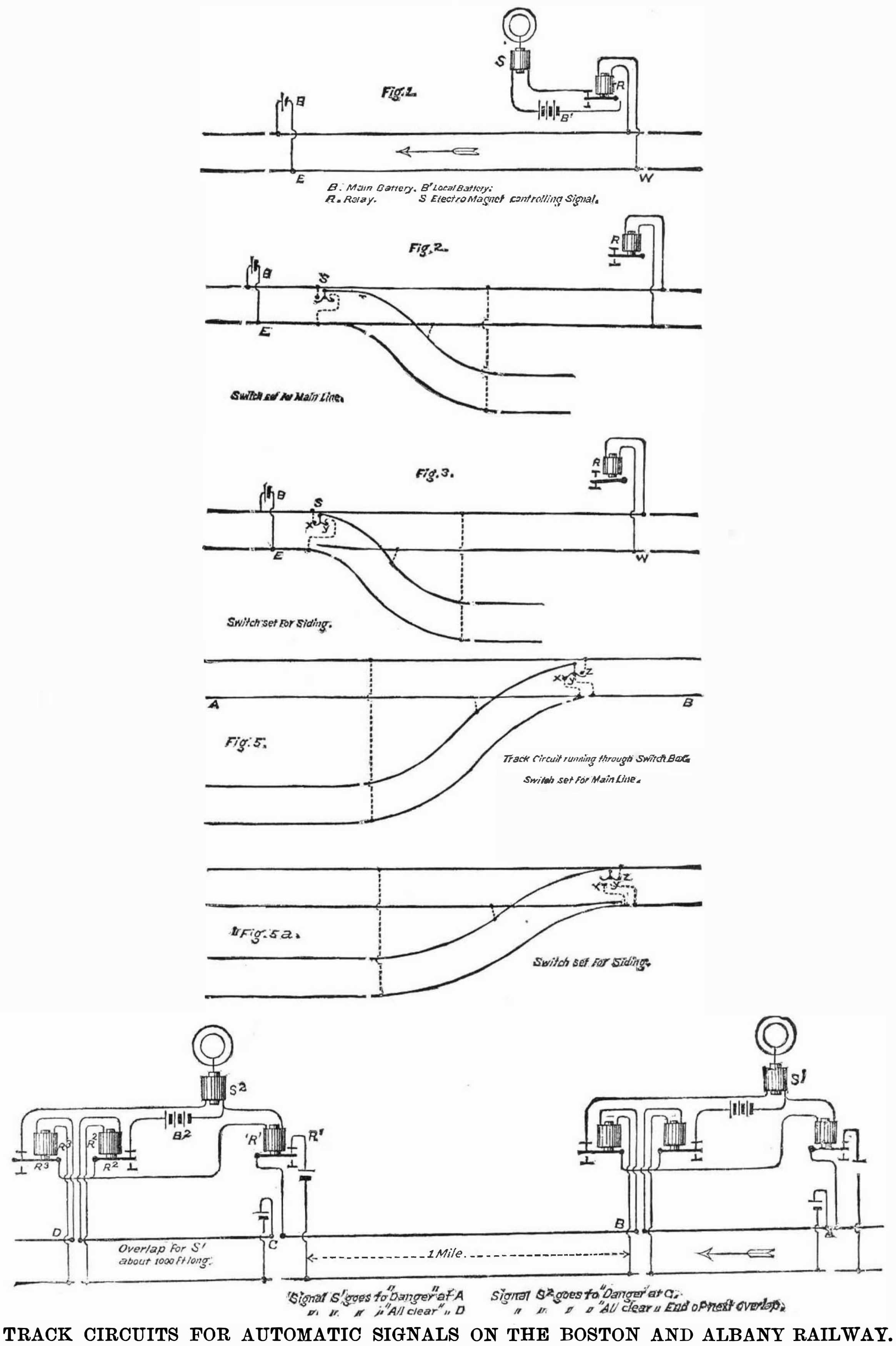
The larger part of the road is equipped with the rail circuit clockwork signals of the Union Switch and Signal Co. The first applications of this signal were made in 1882, when six blocks were put up as an experiment. The remainder of the road which has signals at all is furnished with the old style Hall duplex signals, very much inferior in efficiency and simplicity to those in use on the New York, New Haven & Hartford.

LINE BLOCK SIGNALS WITH RAIL CIRCUITS.

The road is divided into sections of varying lengths, according to the amount of traffic or local circumstances, as above mentioned, each of which sections has a signal at the beginning (operated by clockwork and a weight), which is set to the position indicating danger whenever a train enters the section from any point, and restored to that indicating safety when the train leaves the section. Each section is electrically insulated from those before and behind it. At the end farthest from the signal is an electric battery giving a constant current, which is connected to the track, one pole to each rail. At the signal end of the section, the coils of a relay are connected to the rails in like manner, so that there is a constant flow of electricity from the battery through one line of rails to the relay, thence through its coils to the other line of rails, thence by these rails back to the battery. This relay controls the local circuit (so called) of another battery connected to an electro-magnet in the signal which governs the motion of the clockwork operating it.

Fig. 1 shows the track clear, relay, R, holding the local circuit through S closed.

The successful operation of signals by means of rail circuits requires that the electromotive force (or pressure, as it may be considered) of the battery connected to the rails shall be so small that there will be only



TRACK CIRCUITS FOR AUTOMATIC SIGNALS ON THE BOSTON AND ALBANY RAILWAY.

slight leakage from the rails even in wet weather. It is found advisable, therefore, to include in the track circuit only the coils of a relay of low resistance, and make this relay open and close the circuit for another battery of any size desired, which shall operate the signal mechanism. There are then two electric circuits for each signal; one through the rails controlling another through the signal. Both circuits are normally closed; that is, there is a constant flow of electricity through the whole length of each. The clockwork is so constructed that when the current is passing through the magnet the signal is held in the position of "all clear" or "safety." When this is interrupted, the signal makes one fourth of a revolution to the position indicating "danger" or "stop."

When a train enters the section, the current in the rails takes the path of least resistance through the wheels of the train, instead of the relay magnet. The armature of this magnet then falls off and opens the circuit of the battery controlling the signal, and this takes the "danger" position as long as the section is occupied. When the rear of the train passes out of the section, the circuits are again closed and the signal shows clear; but if so much as a pair of wheels remains in any portion of the section, the signal will continue to show danger until the obstruction is removed. The same effect is produced whenever, for any cause, either circuit is interrupted; if, for instance, the battery fails, or the wires are broken, or the clockwork is run down, the signal shows "danger." If a rail in the track is broken, and the parts separated by so much as $\frac{1}{100}$ of an inch, the signal will be at danger. Many instances of this kind have occurred, and not a few where the indication was most timely. Indeed, the use of automatic signals has often discovered broken rails which might have remained in the track a long time without such displacement of parts as would have rendered them liable to detection by the ordinary methods of inspection.

To make perfect electrical connection between the rails, a wire extends past each joint, the ends of which are connected to the two rails by a tight-fitting pin in a hole drilled in the flange of the rail. While rails are new and fish-plates tightly screwed up, this is not absolutely needed, but as soon as they begin to rust, there is trouble if the rails be not connected by the

Signals are placed a short distance (usually about 200 ft.) beyond the beginning of the section, in order that an engineer may see the signal operate for his train. Should it fail to do so, he is to stop, the same as for a danger signal, and proceed only as the way is known to be clear. The engineer of every train stopped by a signal must without delay report the stop and the cause *if known* (on blank cards provided for the purpose), as, for instance, a preceding train in section or an open switch. If the cause be not apparent to the engineer, he simply reports "cause not known," and it is put in the hands of a repairman to investigate. When the latter has ascertained the cause (for instance, a broken rail, failure of battery, derangement of some part of the apparatus, or other cause not at first apparent), he returns the card with his explanation indorsed thereon. If *he* cannot find out the cause, he returns the card with that statement, and it is usually never ascertained. There is a small fraction of one per cent. of such stops at signals. It is quite certain that some of these are due to previous trains, open switches, or other legitimate causes, but in the absence of positive proof they are not so classified. Sometimes employes needlessly cause stops of trains at signals, and to save themselves the consequences carefully conceal the fact, which is not always afterward discovered, and when this is the case such stops have to be reported "cause unknown." A careful record is kept of all stops and their causes, and every month a debit and credit account is made up of the operation of the signals on each division of the road, which shows at a glance what proportion of stops is due to neglect of employes, defective apparatus, unavoidable causes, etc., as well as all legitimate stops.

The only stops credited to the system are those due to: 1, previous trains in section; 2, open switches; 3, broken rails; 4, repairing track; 5 [sometimes], using single track; 6, cars left on turnouts too near the main track. Lost motion in switches, broken track wires, or any other failure of the track circuit is usually charged to the neglect of trackmen; those due to failure of batteries, corrosion apparatus, and certain other derangements, to neglect of signalmen, so that the blame may be placed where it belongs. Employes are held to a strict account for all avoidable stops caused by them, and the ratio has been reduced to one

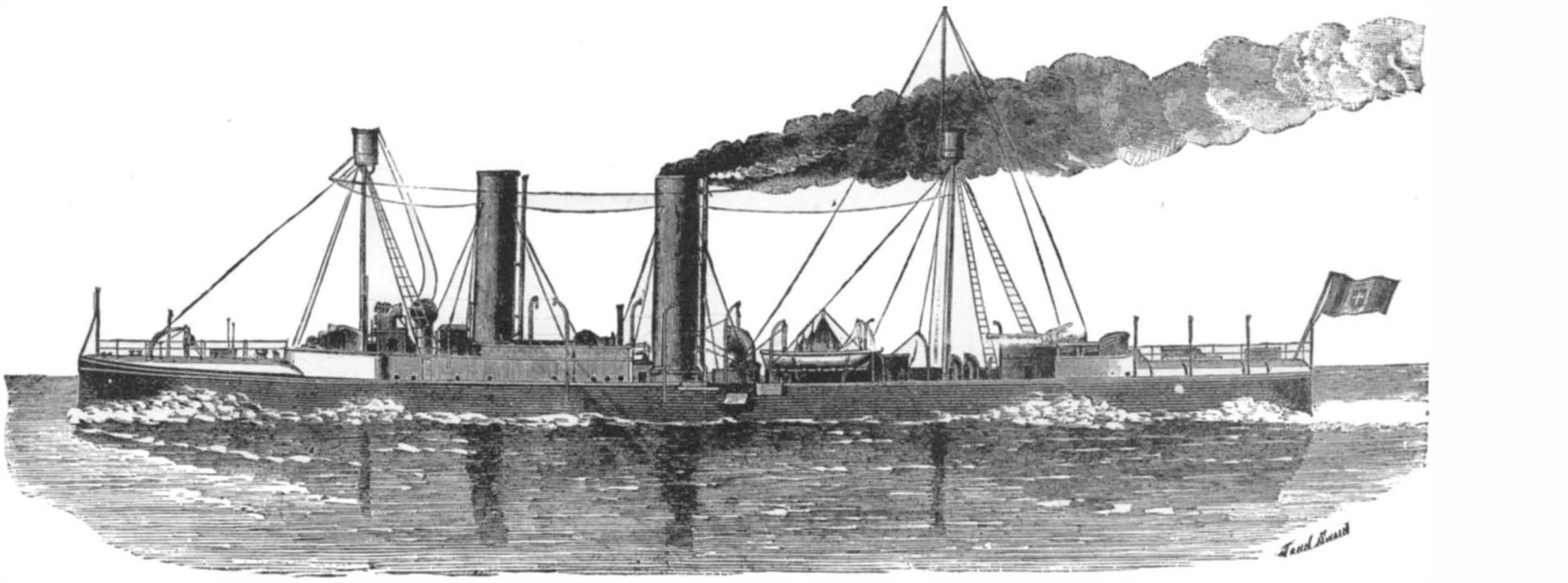
the signalman, and the third may also be. This last may be remedied by a different arrangement of circuits, which the Boston & Albany will adopt in all new work. The fifth may or may not be the signalman's fault. A rain storm sharply followed by freezing weather will stick every signal in an hour in the position it happens to be at the time. A heavy fall of damp snow will sometimes (but rarely) do the same thing.

Another failing case of bad repute is when the signal stands clear with a switch open. This usually shows a faulty connection in the switch box. There is no way (with the arrangement of circuits shown in Figs. 2 and 3) to know beforehand whether opening the switch will set the signal. A far safer connection is shown in Figs. 5 and 5*a*, where the current in the rails is made constantly to pass through the switch box when the switch is on the main line. The switch box must be in good order or the current cannot pass. All the switch connections on the Boston & Albany are now being changed to this style.*

A multitude of causes may make a signal stand at "danger" when no train is in the section, or switch open. Any derangement of the apparatus (except the special ones enumerated above), or interruption of the rail circuit by displacement of the track or otherwise, will do this. Stops thus caused are principally a matter of annoyance and expense. They do not introduce an element of danger, except that, if very frequent, they would tend to make enginemen careless of the indications of the signal when it did warn of existing danger. Though there may be a considerable number of such stops in a month on some divisions of the road, it is found, when account is taken of the number of trains running, that the ratio of failures to number of operations is very small.

THE HALL AUTOMATIC SIGNALS.

Of the Hall signals on the Boston & Albany, little needs to be said. They have none of the latest improvements which make that instrument a model of simplicity and careful construction, and make one wish all the mechanism he uses could be made with equal precision. They have open circuits through wires carried on poles, and give no indication of broken rails, parts of trains left in sections, or cars on turnouts left too near the switches, nor do they profess to do any of these things.



THE NEW ITALIAN CRUISER DOGALI.

wires. Signals have worked for several months with an unwired track, but ordinarily they will do so only for a few weeks, even if rails and fish-plates be perfectly new.

Figs. 2 and 3 show the circuit breakers connected with each switch and the wire connections by which the rails of side tracks are included in the track circuit, for the purpose of keeping signals at "danger" until trains entering the side track are fully clear of the main line. In Fig. 3, points X and Y are connected by the curved flat brass which is held against them by a spring, and the two rails are thus electrically connected the same as when a pair of wheels is upon them. In Fig. 2 the switch rail, T, having been withdrawn from the main track rail has pushed the brass connections away from X and Y, breaking the connection between the opposite rails.*

When the block signals are continuous, that is, with no spaces between the sections, the safety of trains following each other at short intervals is very greatly increased by making the sections *overlap* each other. This causes a signal to remain at danger until the train has passed a certain distance (usually about 1,000 feet) beyond the next signal. While the train is running this short distance there are *two* red signals behind it, one at the beginning of the section where the train is, and the other at the beginning of the preceding section.

The arrangement of circuits which accomplishes this is shown in Fig. 4, which assumes the block to be one mile in length. The principal track circuit for the signal, S^1, passes through the armature of a relay, R^1; the coils of this relay are in a wire circuit connected with the battery, B^2, which is controlled by a relay, R^2, placed at the end of the overlap. The coils of this last relay are connected to the rails of the overlap. It will be seen that a train on any portion of this short section will operate the relay, R^2, and consequently R^1, and set both signals. Hence, so long as an engineman does not pass a red signal he can never approach a preceding train nearer than the length of the overlap.†

* In Figs. 2 and 3, B is the battery at one end of the block section, and R the relay controlling the signal at the other end. The switch, S (or any number of switches), may be at any point between these two.

† When a train is on the section C D, relay R^2 is demagnetized, thus opening both the circuits through battery, B^2. S^2 and S^1 then both show "danger." When a train is in the section beyond D, relay R_3 is demagnetized, holding S^2 to "danger." Signal S^2 stands 200 feet from C and 800 feet from D.

surprisingly small. To the debit side of the account is charged all such stops as are caused by defective construction of any part of the apparatus. The number of these has heretofore been unreasonably large. First class mechanical construction costs but little, if any, more than such as would not pass inspection in any good machine shop, and gives immeasurably better satisfaction in service.

There remain a certain number of stops due to "unknown" causes, and certain other stops due to climatic conditions, unavoidable accidents to the apparatus, derailments, lightning, etc., which are grouped by themselves under the head of "accidental." Longer experience will doubtless suggest ways in which the number of these may be diminished.

The selling agents for railroad signals are fond of asserting that, in their particular system, "it is impossible for a signal to show safety if danger exists." They rarely, if ever, make known that there are any weak points or loopholes for failure in their systems, sometimes (it may charitably be assumed) because they do not know them, never having had any practical experience of their working except in a model room; but the severe tests of actual service under all varieties of climate and temperature show that the perfect railroad signal has not yet been invented. In each system certain deficiencies, or failing cases, must be provided against in order that the signal may work regularly or be used with safety.

The most dangerous error an automatic signal can make is to show clear when a train is in the section. The Union signal is perhaps more free than any other from such failures, but they are by no means unknown. The cases which have come under my own observation have been due to: 1, a failure of the track circuit relay to drop its armature when the current was shunted out of the magnet; 2, too much battery on the rail circuit; 3, crossed wires between the signal and overlap relay; 4, failure of the signal magnet to release the clockwork when the circuit was opened; or 5, the sticking of some mechanical part of the apparatus which should have moved freely.

Of these the first is by far the most common except in ice and sleet storms; like the fourth, it is usually due to fixed magnetism in the cores or armature of the relay, and could be prevented by the use of better iron in their construction. The second cause is the fault of

The most serious errors they have ever made have been due to a train entering a section already occupied. Trains are sometimes obliged to do this, but must take certain precautions. When the first train passes out of the section it reverses the signal behind the second train, leaving it with no protection whatever. If now a *third* train enters the section, it does so with the assurance of a clear track, and may discover the second train when too late to make a safe stop. Collisions have resulted from circumstances of this kind.

The cost of operating each Union signal, including superintendence, was, during the year ending Oct. 1, 1886, about $75.69, or $6.31 per month. The cost of each Hall signal was, for the same period, $174.26, or $14.52 per month.

There are roads equipped with Union signals which claim to have fewer unnecessary stops per signal than the Boston & Albany, and to run their signals at less expense, but they have for the most part no overlapping sections (which very much increases the simplicity of their applications), their trains run at longer intervals, and in some cases the account of stops and their causes is not so carefully kept.

In conclusion, the results obtained, while not all that could be desired, are such as to lead to a large degree of confidence in rail circuit signals. In point of safety and reliability of indication they are a long way in advance of other systems, and the rail circuit is an absolutely essential feature of automatic line block signals, which propose safety as one of their characteristics.

GEO. W. BLODGETT.

THE ITALIAN CRUISER DOGALI.

IN our descriptive article of June 25, we spoke of the vessels which were turned out complete at Elswick for the British and foreign governments. Incidentally in the same number was introduced a cut of the Victoria in connection with the Sanspareil, her sister ship, which was launched lately at the yard of the Thames ironworks. The 110½ ton guns for both vessels are made at Elswick. We use the expression vessels complete being supplied from the establishment as in-

* The current in the rail A B, when the main track is unbroken, must normally pass through the points X Y; when the switch is moved, the connection between X and Y is broken and the opposite rails connected (as by a pair of wheels) through Y and Z.

cluding the ships and their armament. Having noticed the Victoria, we give herewith an illustration of a swift cruiser recently completed for the Italian government—a class that is known to be especially needed by us now that attention has been turned to the great vulnerability of our commerce. The vessel in question was built and launched under the name of Salaminia. She was subsequently called Angelo Emo, and finally, after the recent Italian engagement at Dogali in Massowah, the vessel took the name of the Dogali. We believe that no account of her exists in print, nor is she to be found under any of the names in Lord Brassey's annual or other lists published in this country, so far as we know. The view we give is taken from an instantaneous photograph made of the vessel during her trial for speed, and is of some interest as showing her behavior, so far as can be by an engraving, when moving through the water at a speed of between 19 and 20 knots. The particulars concerning her are as follows:

Length over all	267 ft.
Length between perpendiculars	250 ft.
Breadth, moulded	37 ft.
Depth, moulded	20 ft. 6 in.
Draught of water, forward	13 ft.
" " aft	16 ft.
" " mean	14 ft. 6 in.
Displacement	2,050 tons.
Indicated horse power:	
Natural draught	5,000 tons.
Forced draught	7,700 tons.
Speed—forced draught	19·66 knots.

Armament: Six 6 in. breech loading guns on center pivot Vavasseur mountings, nine 6 pounder rapid fire guns on recoil carriages, six Gardner guns, one bow torpedo gun fixed, one stern torpedo gun training, two broadside training torpedo guns. The vessel has twin screws, each propeller being driven by a triple expansion horizontal direct acting engine. Storage is provided for 500 tons of coal, which would serve at maximum speed for a run of about sixty hours, or 1,100 knots, or at half speed for about twenty days, or 4,500 knots. The vessel is rigged with two military masts, with light fore and aft sails. The tops are arranged as revolving towers, completely hiding the gunners. Each top carries one Gatling gun. The whole length of the hold of the vessel from stem to stern is protected by a steel deck of a minimum thickness of 1 in. and a maximum of 2 in. The vessel carries two search lights of 20,000 candle power, and a complete outfit of internal lighting.

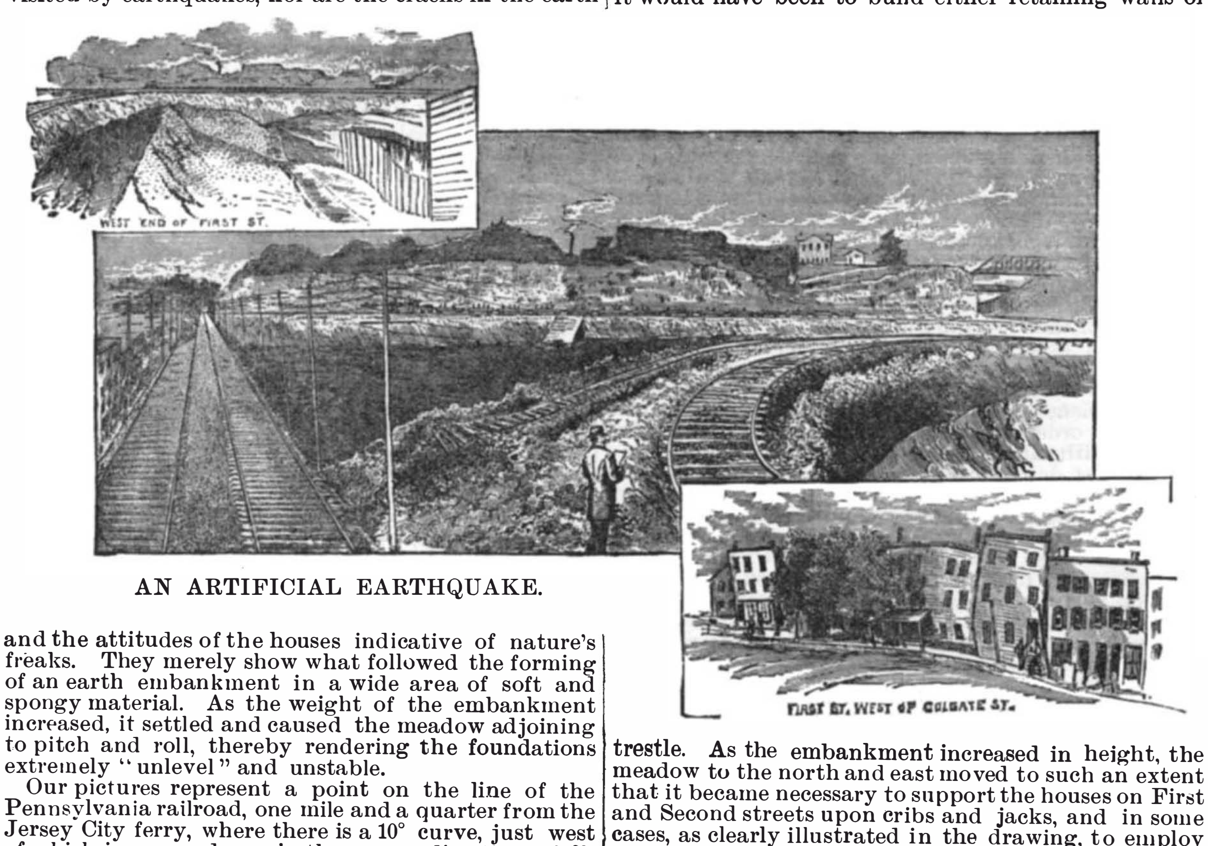
This vessel is the first war-ship fitted with triple expansion engines. They were made by Messrs. R. & W. Hawthorn, Leslie & Co., of Newcastle on Tyne, and are of the twin screw horizontal type. Each set of main engines has three cylinders, 30 in., 45., and 73 in. diameter, with a stroke of 2 ft. 9 in. The slides are worked on Marshall's system, which admits of a very large range of expansion being adopted, and gives as equable a distribution of steam when working at low speeds as when working at full power. The propellers are three bladed. The whole of the engine pumps are driven by separate independent engines. The condensers are of brass. Steam is supplied from four boilers, each having six furnaces, capable of being worked either with natural or with forced draught. The air for the forced draught is supplied by eight fans, each driven by a separate Brotherhood engine. The whole of the auxiliary engines may be made to exhaust either into the main condensers, auxiliary condenser, or into the atmosphere. The engines are situated in two separate water tight engine rooms, the communication between which may be closed at any time by water tight doors moving horizontally, worked from the deck. The boilers also are placed in two water tight stokeholes. This subdivision of the vessel, and the fact that the whole of the auxiliary engines, as well as the main engines, are in duplicate, renders the chances of a complete breakdown very remote. During the trial the engines worked well, running at a speed of 155 revolutions per minute, and developing a power of over 7,600 horses, the vessel attaining a speed of 19·66 knots per hour.—*The Engineer.*

AN ARTIFICIAL EARTHQUAKE.

THE illustrations herewith do not show a region visited by earthquakes, nor are the cracks in the earth and the attitudes of the houses indicative of nature's freaks. They merely show what followed the forming of an earth embankment in a wide area of soft and spongy material. As the weight of the embankment increased, it settled and caused the meadow adjoining to pitch and roll, thereby rendering the foundations extremely "unlevel" and unstable.

Our pictures represent a point on the line of the Pennsylvania railroad, one mile and a quarter from the Jersey City ferry, where there is a 10° curve, just west of which is a second one, in the reverse direction, of 6°. The road is being so far straightened as to require but two curves, each of 3°, thereby reducing the curvature nearly two-thirds in a distance of 2,400 feet. One of the accompanying drawings shows the location of the old line and the embankment for the new. Mt. Pleasant, a hill between the two lines, is being removed, and the rock, which constitutes about ninety per cent. of the whole, is broken up for ballast, while the earth serves as part of the fill. When leveled, this entire area will be used as a yard for passenger cars, and will contain a large roundhouse.

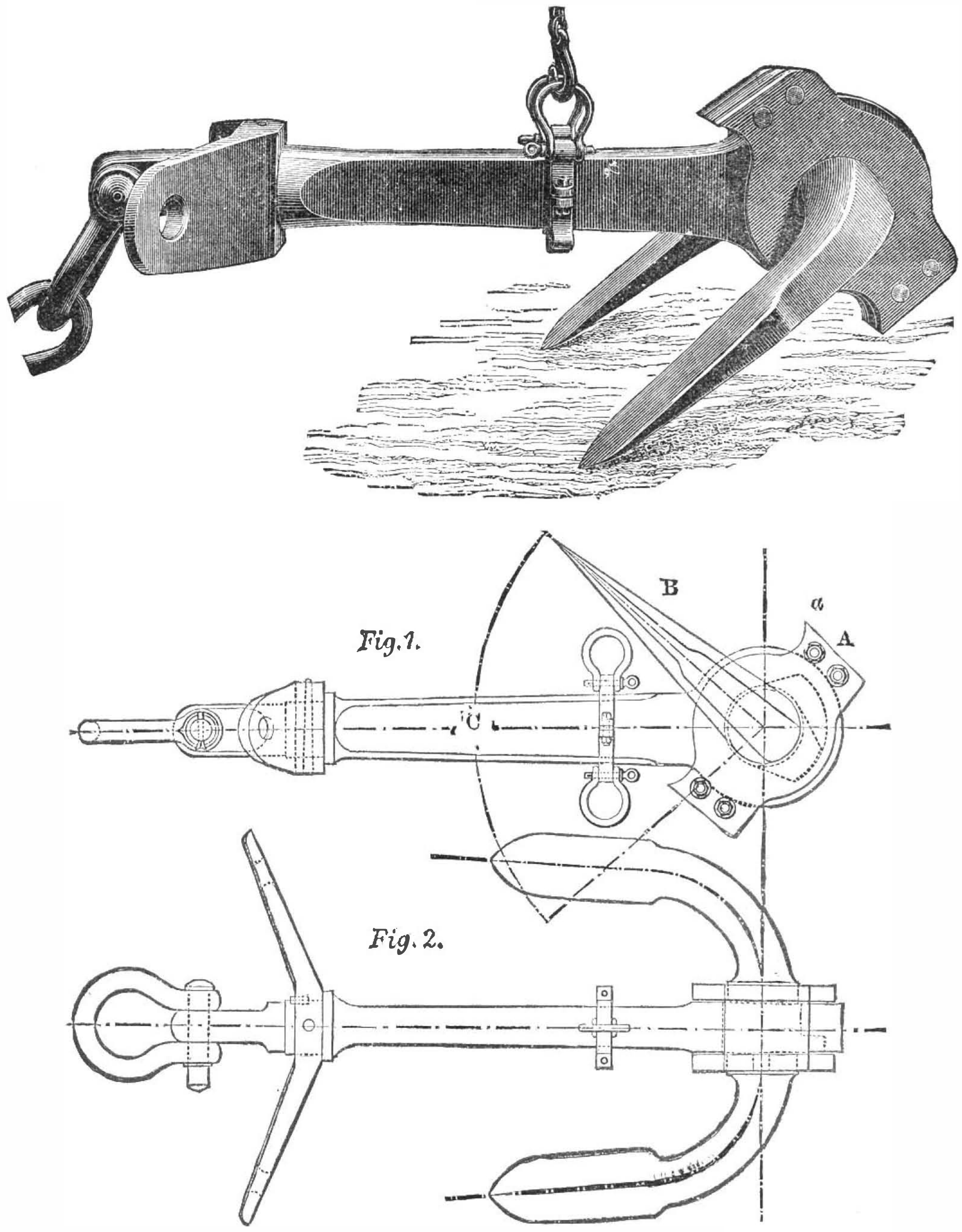
A peculiar feature attended the prosecution of this work. From the base of the hill east, or toward the river, the land was formerly a salt marsh, the soft black mud of which is from 40 to 60 ft. deep, and rests upon sand, gravel, and clay. It was anticipated that the filling necessary for the road would create a disturbance in the land adjoining the embankment, and the adjacent property was therefore purchased by the company and the streets vacated. The company was led to take this course since it required the land for railroad purposes, and as it was more economical to buy and fill in than it would have been to build either retaining walls or trestle. As the embankment increased in height, the meadow to the north and east moved to such an extent that it became necessary to support the houses on First and Second streets upon cribs and jacks, and in some cases, as clearly illustrated in the drawing, to employ shoring. This entire tract will ultimately be filled in and occupied by the railroad. In every instance the movement of the ground was slow and regular, so that it was comparatively easy work to prevent the houses from getting too far from the perpendicular.—*Railroad Gazette.*



AN ARTIFICIAL EARTHQUAKE.

THE MARTIN ANCHOR.

AMONG the exhibits at the exhibition by Hawks, Crawshay & Co. are some fine specimens of solid welded bridge tiers, cables, anchors, and a colossal mooring screw, with shank, crosshead, and swivel complete. An improved Martin anchor shown among their exhibits is here illustrated.



IMPROVED MARTIN ANCHOR, NEWCASTLE EXHIBITION.

The principal modification in this anchor on the old type consists, says *Engineering*, of a simple but effective arrangement of the head, which acts as a lever on the flukes, compelling them to take the ground immediately the strain is applied through the cable. The head, A, is fixed at right angles on the flukes, B, and moves freely round the end of the shank, C. The elongation of the head on both sides is peculiarly shaped at *a*, to act as tipping points, and this part resting on the ground when the anchor is down, the superincumbent weight causes it to bite firmly, whether in hard or soft ground. Immediately the strain is applied, the resistance of the ground to the tipping points, *a*, compels a rotary movement and turns the flukes into the ground. The anchor is weldless, the flukes are composed of one solid forging and the shank of another, while the severe strains due to mooring are entirely confined to these two solid forgings, without the intervention of bolts, pins, keys, cotters, etc.

In 1885, the British government made a series of trials with different anchors against those of the ordinary Admiralty pattern, resulting in the decision that this improved Martin anchor was the best, for reasons of its superior holding power, simple construction, and prompt action. One of the service journals published at the time the following particulars:

"The dockyard authorities at Portsmouth have completed a protracted series of trials of patent anchors, which were tried, weight for weight, against the Admiralty pattern. The tests, which were carried out under the superintendence of the captain of the steam reserve, captain of the yard, and the chief constructor, consisted of dropping the anchors into the harbor mud at low tide and pulling upon them from a lighter, and the one which resisted the greatest strain, thereby demonstrating its superiority, was the Martin improved anchor, and which was found to be in every way superior."

CIRCULAR SAWS AND BAND SAWS.

AT a recent meeting of the Institution of Civil Engineers, London, the paper read was on "The Conversion of Timber in the Pine Growing Districts of the U.S.A. by Circular Saws and Band Saws," by Mr. L. H. Ransome, Stud. Inst. C. E.

During a recent visit to the United States, the author was struck with the ease and rapidity with which rough logs were handled and converted into lumber, and thought a short paper on the subject might be of

interest. The center of the pine growing district is Michigan, and the Saginaw Valley, in that State, turns out probably more lumber than any other timber producing district of like extent in the world. The sawmills are situated on the banks of the river, between the towns of Saginaw and Bay City. The general arrangements of all the mills is much the same. They are built of wood, in two stories, the machinery being fixed on the upper floor, while the lower floor, or basement, is reserved for the shafting, belting, and foundations of the heavier machines. They are generally situated at the river side, the end at which the timber enters being close to the water's edge. The logs, which have been floated down the river from the woods where they have been felled, are collected in the millboom, a space of water inclosed to prevent them from drifting away. A man stationed on a platform in the water guides the floating logs one by one into a wooden trough, inclined from the water to the upper floor of the mill, up which the logs are carried by dogs fixed at intervals to an endless chain constantly revolving in the trough. On arriving at the mill floor, the logs are deposited on V shaped driven rollers, provided with spurs, which deliver them on to a platform. A man standing on this platform controls, by means of a lever, a steam log flipper, with an incline toward the carriage of the circular or the band saw, as the case may be. The logs are held in position while being fixed by an ingenious machine commonly known as a "steam nigger." Several methods of feed are employed in these mills; but the usual plan consists of a steam cylinder fixed immediately below the floor line, and corresponding in length with the traveling carriage. In addition to the large circular saws or band saws, a vertical frame, or gang saw, is employed for cutting the slabbed logs into boards of any required thickness.

In order the better to appreciate the respective merits of circular saws and band saws, the construction of both machines was described, as well as of the mode of treating the saws in each case, their relative advantages being considered under the following heads: 1. Rapidity of production. 2. Quality of work. 3. Power consumed. 4. Waste of wood.

As regards rapidity of production, the circular saw has at present a decided advantage, producing on an average in white pine 50,000 square feet of lumber, 1 in. thick, in a day of ten hours, while the band saw in the same time turns out on an average about 35,000 ft. It should, however, be borne in mind that the circular saw, having been in use for so many years, has probably reached its utmost limit of production, while, on the other hand, the band saw, having been but recently introduced for this purpose, is capable of considerable further development. This assumption is confirmed by the fact that a band sawmill of the most improved construction has been known to produce as much as 52,000 ft. in a day of ten hours, the product of 102 logs.

As regards quality of work, the advantage is undoubtedly on the side of the band saw, for whereas it is practically impossible to run a large circular saw at a high velocity without a certain amount of vibration, which naturally produces a somewhat rough surface, a band saw, being packed immediately above and below the cut, passes through the log in a straight line; and moreover, as the teeth of a band saw are considerably finer than those of a circular saw, they produce a smoother surface.

It is unfortunate that, owing to the question of power being so little considered in America and to the fact that the application of the band saw for logs is comparatively new, no authentic tests as to the power required by the latter machine have as yet been made with the indicator; but by comparing the engines usually employed to drive both the band and the circular mills, an approximate idea on this point may be arrived at. To drive a circular mill with a 6 ft. saw, an engine with a cylinder 18 in. in diameter, a piston travel of 500 ft. per minute, and an average pressure on the piston of 40 lb. to the square inch, is generally employed. Such an engine develops 154 indicated horse power. To drive a full-sized band mill, an engine with a cylinder 12 in. in diameter, working under similar conditions as to piston speed and average pressure, is recommended. This would develop about 68 indicated horse power, or considerably less than one half that required to drive a circular mill.

The last, but certainly not the least, important point is the question of waste of wood; and here again the band saw gives by far the best results. The amount of wood lost in sawdust per cut by a circular saw is $\frac{5}{16}$ in.; therefore, when producing boards 1 in. thick, the waste is 24 per cent. A band saw at most wastes $\frac{1}{8}$ in. per cut, or, when cutting 1 in. boards, 11 per cent. Again, to make a board cut by a circular saw, when planed on both sides, hold up to $\frac{7}{8}$ in., it must be cut 1 in. thick, *i. e.*, $\frac{1}{16}$ in. must be allowed on each side for planing; while, on the other hand, owing to the superior cutting of the band saw, it is only necessary to allow $\frac{1}{32}$ in. on each side for planing, showing an additional saving of $\frac{1}{16}$ in. per cut. This gives a total saving of $\frac{1}{4}$ in. per cut by the use of the band saw.

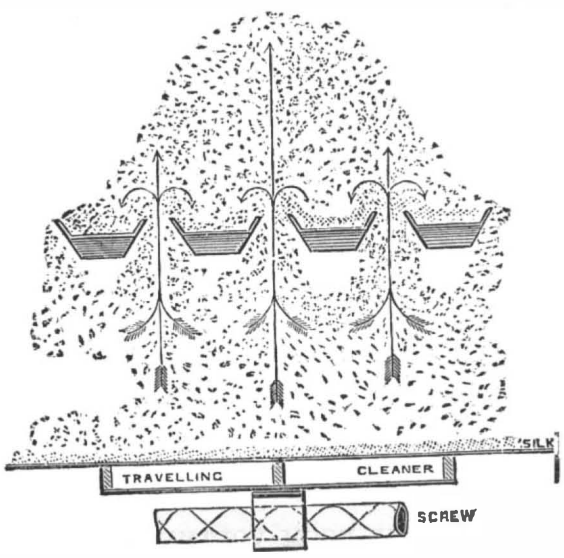
The foregoing calculations apply to timber of such a size as can be converted by a circular saw 6 ft. in diameter; but for larger logs it is necessary to employ an overhead saw, and as the tracks of the two blades never exactly coincide, the boards thus sawn show a joint, which necessitates a still further waste of wood. This objection does not apply to the band mill, which will saw through logs of any diameter.

It is thus evident that, for the conversion of pine logs, the balance of advantage lies distinctly with the band saw; and if this is so in the case of comparatively small and cheap timber, it is certain that for the more valuable descriptions of hard woods, which frequently run to very large sizes, these advantages would be enormously increased; and it is not too much to say that the band saw will, in a few years, be universally employed in preference to any other machine for the wholesale conversion of timber.

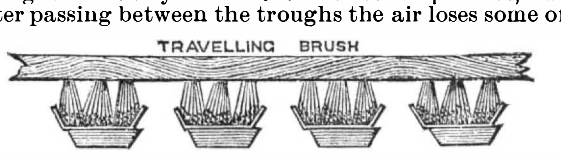
ACCORDING to a statement by Mr. J. A. Longridge, the brag that the new English 110 ton gun has fired the largest charge of powder ever set off in a cannon is without special practical value, the probability being that a considerable portion of the charge went out of the gun without being burned. The Krupp 122 ton gun, with a charge of 848 pounds of powder, is proved to have a penetration of four inches more of iron than the English gun with 1,000 pounds of powder.

A NEW PURIFIER.

A NEW purifier has been made by Messrs. Thomas Robinson & Son, the novel parts of which are here illustrated. For treating middlings it operates in a manner quite new, and the makers claim for the machine the separation of an intermediate product not previously obtained, that it is equally efficient in purification on the finest middlings as on coarse semolina,



and that by its use a great reduction in the area of the dust room or dust collector is possible. And further that with their traveling filter cloth no dust collector or trunking is required. The action of the machine will be readily understood from the following description: Above the silks are placed a number of U shaped troughs, which are fixed so close together that the upward current of air is greatly intensified when passing between them, and a comparatively light draught will carry with it the heaviest impurities, but after passing between the troughs the air loses some of



its velocity, and can only carry away the very lightest impurities to the stive room; the heavier particles then fall into the troughs. Thus a new product is obtained, which formerly either fell back on to the silk or was partly carried away into the stive room and partly deposited on corners or chambers. The troughs are automatically cleaned by means of a traveling brush, which sweeps the impurities into a worm at the tail end of the machine, whence they are spouted away as desired. The exhaust chamber over the sieves is divided into separate compartments, which are so arranged that the draught can be adjusted to suit the different sizes of middlings in the various stages of purification. It is fitted with Messrs. Robinson's automatic vibrating feed, which they say "delivers the middlings in a perfectly even strain across the whole width of sieve."—*The Engineer*.

CONCENTRATION OF SULPHURIC ACID AT THE MANCHESTER EXHIBITION.

MESSRS. R. & J. GARROWAY, Glasgow, show samples of vitriol, unconcentrated, concentrated, and double, pyrites vitriol, engravers' nitric acid, aquafortis, braziers' aquafortis, marine acid, sulphurous acid, bisulphite of lime, caustic soda, soda ash, salt cake, niter cake, oxalic acid, nitrate of iron, nitrate of copper, feathered refined tin, tin crystals, oxymuriate of tin, single and double muriates of tin, solid stannate of soda, Glauber's salts, Epsom salts, red liquor, acetic acid, borax, boracic acid, and numerous other chemicals. A model of the works is also exhibited.

This firm have a patent process for the manufacture and concentration of sulphuric acid. The improved apparatus consists of a series of open beakers, basins, or tubes of hard Bohemian glass or glazed ware, cylindrical, or nearly so, in form, fitted within a flue or flues, and connected so that acid or liquor may flow continuously through the series. This arrangement of beakers or other vessels is placed on a sand bath, within the flue which conducts the sulphur fumes from the sulphur or pyrites furnaces to the oil of vitriol chambers. Through the series of vessels a continuous slowly moving stream of nitrous vitriol is passed. The hot sulphurous fumes passing over this stream of liquor liberate the nitrous acid, which passes away to the oil of vitriol chamber, and is therein deoxidized in the formation of sulphuric acid. By these means a considerable saving of niter is said to be obtained, and the apparatus may be erected at considerably less cost than the Glover's tower, for which it is substituted.

The accompanying illustration will serve to make clear the nature of the apparatus. Fig. 1 is a longitudinal vertical section, Fig. 2 a horizontal section, and Fig. 3 a transverse vertical section of a modification of the improved apparatus for use in the manufacture and concentration of sulphuric acid. Figs. 4 and 5 show modified arrangements of the improved beakers or other concentrating vessels.

In making use of this apparatus, cylindrical beakers, basins, or tubes, B, made of hard Bohemian glass or glazed ware, are placed within the flue or flues, F, and connected in such a manner that acid may flow continuously through the whole series. The vessels may be placed on the bottom of a sloping or inclined flue, or in a long compartment, F', forming part of the main flue, F, as represented in Figs. 1, 2, and 3, and they may be connected by glass siphon tubes, S, the ends of which dip into the liquor in each adjacent pair, as in Fig. 4. In a modified arrangement, the beakers have a projecting lip, B', on one or both sides, and are arranged on a slope, so that the liquid entering the highest vessel, B, overflows into the second, and each in turn into the next continuously; or the same form of beakers or basins, B, may be made of several different sizes or of different heights, as shown in Fig. 5, so that a set of two or more similarly connected may be placed on a step at one level, and so arranged that the liquor overflows into the lower set or sets. When in use, the series of open vessels, B, is placed in a sand bath, A, within the flue, F', which leads the sulphur fumes from the ovens or furnaces, O, to the oil of vitriol chambers. A continuous slowly moving stream of nitrous vitriol from the "Gay-Lussac towers" is passed through the series of beakers, B, and coming in contact with the hot sulphurous fumes from one or more of the ovens, O, the nitrous acid is liberated, and passes away to the oil of vitriol chambers, where it is deoxidized in the formation of sulphuric acid. The beakers may, if necessary, be heated by means of hot waste gases passing through a flue beneath the vessels, in order to assist the expulsion of the nitrous acid from the sulphuric acid. The drawing off of the liquid from the last beaker, B, may be accomplished by a siphon, S, connected to the beaker, and passing out through the wall of the flue. The acid is then usually sufficiently concentrated to be admitted directly to the platinum still.—*Industries.*

SIR WILLIAM THOMSON'S NEW ELECTRIC MEASURING INSTRUMENTS.

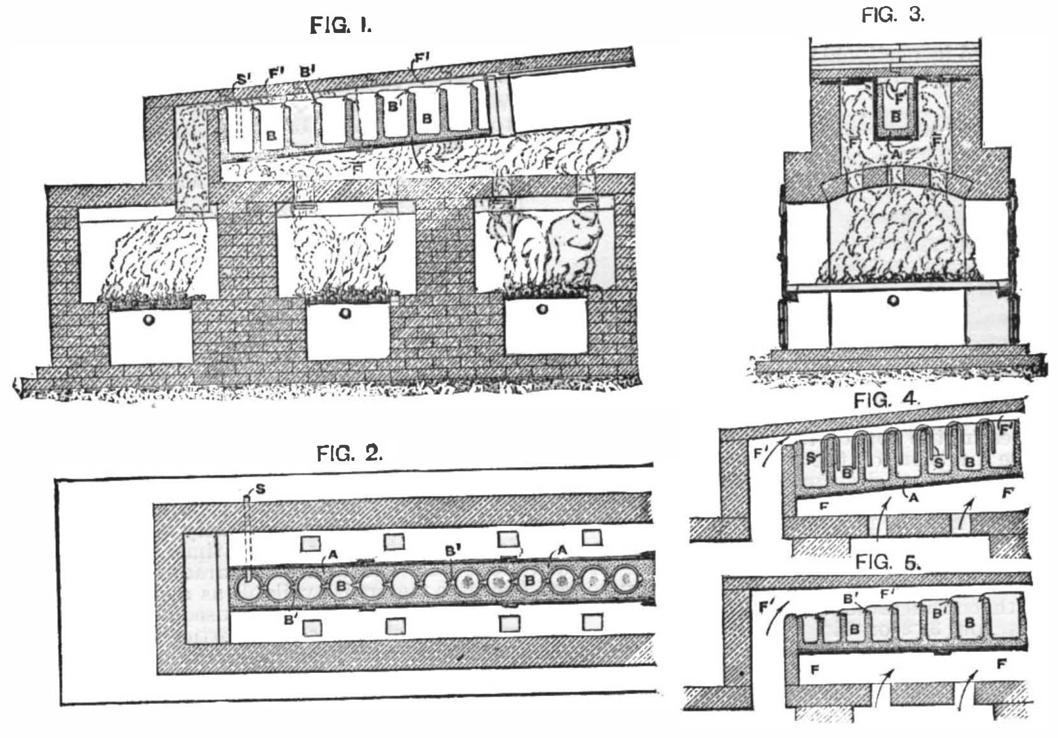
STANDARD ELECTRIC BALANCES.

1. THESE instruments are founded on the mutual forces, discovered by Ampere, between movable and fixed portions of an electric circuit. The shape chosen for the mutually influencing portions is circular, and each such part will be called for brevity an ampere ring, or sometimes simply a ring, whether it consists of only one turn or of any number of turns of the conductor.

2. In the balance instruments each movable ring is actuated by two fixed rings, all three approximately horizontal. In each of the balance instruments there are two such groups of three rings—two movable rings attached to the two ends of a horizontal balance arm pulled, one of them up and the other down, by a pair of fixed rings in its neighborhood. The current is in opposite directions through the two movable rings to practically annul disturbance due to horizontal components of terrestrial or local magnetic forces. In the direct reading voltmeter there is only one fixed ring acting on a single movable ring, which is attached to one end of the balance arm and counterpoised by a weight at the other end.

3. In all the instruments the balance arm is supported by two trunnions, each hung by an elastic ligament of fine wire, through which the current passes into and out of the circuit of the movable rings or ring.

4. In the balance instruments the mid-range position



APPARATUS FOR THE CONCENTRATION OF SULPHURIC ACID.

of each movable ring is in the horizontal plane midway or nearly midway between the two fixed rings which act on it. The current goes in opposite directions through the two fixed rings, so that the movable ring is attracted by one of the fixed rings and repelled by the other.

5. In the balances to measure direct currents of from 5 amperes to 1,000 amperes, the outer diameter of each pair of fixed rings is somewhat smaller than the inner diameter of the movable ring, and the proportions are so arranged that the force experienced by the movable ring is very nearly constant through half a centimeter on each side of its middle position. This is the sighted position for the ordinary use of the balance, and it is marked by the zero line or middle one of five stout black lines across the scale traversed by the pointer of the balance.

6. In the balance instruments to measure alternate currents of all strengths, and direct currents of from 5 milliamperes to 10 amperes, the fixed rings are larger than in the instruments to measure the larger direct currents. Their outer diameters are greater and their inner diameters less than that of the movable ring which moves between them, above one and below the other. The position of the movable ring equidistant from the two fixed ones is a position of minimum force, and the sighted position, for the sake of stability, is above it at one end of the beam and below it at the other, in each case being nearer to the repelling than to the attracting ring by such an amount as to give about $\frac{2}{10}$ per cent. more than the minimum force.

7. In the balance instruments to measure alternating currents (which may be also used for direct currents) of from 5 amperes to 1,000 amperes, the main current through each circle, whether of one turn or of more than one turn, is carried by a wire rope of which each component wire is insulated by silk covering or otherwise from its neighbor, in order to prevent the inductive action from altering the distribution of the current across the transverse section of the conductor.

8. The balancing is performed by aid of a weight which slides on an approximately horizontal graduated arm attached to the balance, and there is a trough fixed on the right hand end of the balance, into which the proper counterpoise weight is placed, according to the particular one of the sliding weights in use at any time (§ 11 below). For the fine adjustment of the zero a small metal flag is provided (as in an ordinary chemical balance) actuated by a fork, with a handle below the case outside as shown in the drawing. To set the zero, the left hand weight is placed with its pointer at the zero of the scale, and the metal flag is turned to one side or the other until it is found that, with no current going through the rings, the balance rests in its sighted position.

9. To measure a current, the left hand weight is slipped along the scale until the balance rests in its sighted position. The strength of the current is then read off approximately on the fixed white scale (called the inspectional scale) with aid of the finely divided scale, for more minute accuracy, according to the explanations given in § 13 below. Each number on the inspectional scale is twice the square root of the corresponding number on the scale of equal divisions.

10. The slipping of the weight into its proper position is performed by means of a self-releasing pendant hanging from a hook carried by a sliding platform, pulled in the two directions by two silk threads passing through holes to the outside of the inclosure.

11. Three pairs of weights (sliding and counterpoise), in the ratios of 1 : 4 : 16 or 1 : 4 : 25, are supplied with each instrument, adjusted so that each pair gives a round number of amperes or half amperes or quarter amperes, or of decimal subdivisions or multiples of these magnitudes of current, on the inspectional scale.

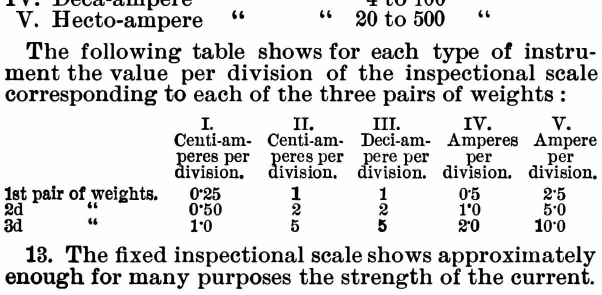
12. The useful range of each instrument is about from 1 to 25 of the smallest current for which its sensibility suffices. The ranges of the different types of this instrument regularly made are :

I. Centi-ampere balance :	from	2 to 50 centi-amperes.
II. Deci-ampere "	"	1 to 25 deci-amperes.
III. Ampere "	"	1 to 25 amperes.
IV. Deca-ampere "	"	4 to 100 "
V. Hecto-ampere "	"	20 to 500 "

The following table shows for each type of instrument the value per division of the inspectional scale corresponding to each of the three pairs of weights :

	I. Centi-amperes per division.	II. Centi-amperes per division.	III. Deci-ampere per division.	IV. Amperes per division.	V. Ampere per division.
1st pair of weights.	0·25	1	1	0·5	2·5
2d "	0·50	2	2	1·0	5·0
3d "	1·0	5	5	2·0	10·0

13. The fixed inspectional scale shows approximately enough for many purposes the strength of the current.



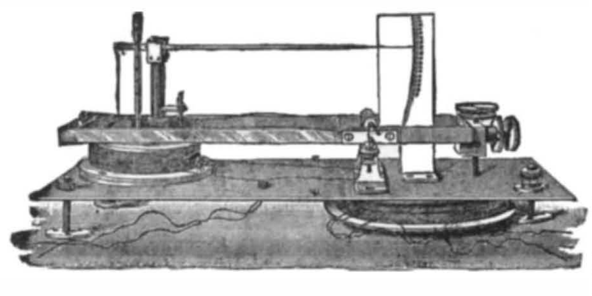
STANDARD ELECTRIC BALANCE.

The notches in the top of the aluminum scale show the precise position of the weight corresponding to each of the numbered divisions on the white scale, and practically annul error of parallax due to the position of the eye. When the pointer is not exactly below one of the notches corresponding to integral divisions of the inspectional scale, the proportion of the space on each side to the space between two divisions may be estimated with considerable accuracy. Thus we may readily read off 34·2 or 34·7 by estimation with little chance of being wrong by one in the decimal place. But when the utmost accuracy is required, the reading on the fine scale of equal divisions must be taken, and the strength of current estimated by aid of the table of doubled square roots appended to these instructions. Thus, for example, if the reading is 292, we find 34·18, or say 34·2, as the true scale reading for strength of current. Or, again, if the balancing position of the pointer be 301 on the fine scale, we find 34·65 as the true reading of the inspectional scale.

14. The centi-ampere balance, with a thermometer to test the temperature of its ampere rings, and with platinoid resistances up to 2,000 ohms, serves to measure potentials of from 10 volts to 200 volts.

DIRECT READING VERTICAL SCALE VOLTMETER.

This instrument is commonly called "engine room voltmeter," because it can be read at such a distance as across an engine room, and requires for taking a reading no balancing manipulation, as in the balance ampere meters. It is convenient not only for engine rooms, but for use in any part of an electric light installation, or in houses supplied with electric light. It shows, by inspection, whether the potential is exactly the proper amount, or, if not exactly so, by what fraction of a per cent., or by what percentage, down to 10



ENGINE ROOM VOLTMETER.

per cent. below or up to 10 per cent. above, it differs from the proper amount.

The inspectional voltmeters consist of :

a. A fixed platinoid resistance, in circuit with a fixed and a movable ampere ring.

b. A V trough rigidly fixed to the movable ring, and carrying the weight proper to the potential to be measured and the temperature of the instrument.

c. A thermometer to show the temperature of the ampere rings.

d. A lever multiplying the motion of the movable ring, and showing the potential to be measured on a vertical graduated scale.

The fixed and movable ampere rings are each composed of many turns of fine insulated copper wire, with a total resistance of about 100 ohms. The amount of the added platinoid resistance depends on the potential to be measured in the ordinary use of the instrument. Thus, for example, for potentials of from 10 per cent. below to 10 per cent. above 100 volts, the platinoid resistance is 700 ohms. For potentials of from 10 per cent. below to 10 per cent. above 200 volts, the platinoid resistance is 1,500 ohms.

18. Temperature error is practically annulled in the use of the instrument by simply reading the thermometer (14 *b* and *c*), and seeing that the weight in the trough is the one corresponding to the temperature. Five weights, corresponding to temperatures Centigrade of 15°, 20°, 25°, 30°, 35°, are supplied with the instrument in receptacles marked with the temperature, so that no mistake can be made in seeing that it is the right weight that is in use on the instrument at any time.

MARINE VOLTMETER.

19. The mass of the moving part of the balance voltmeter and engine room voltmeter is too great to be convenient for sea use, and instead a small oblate of soft iron supported on a stretched platinoid wire in the center of a solenoid of fine copper wire, connected in series with platinoid resistances, variable according to the potential to be measured, serves for marine voltmeter. A pointer carried by the oblate shows, by inspection, direct reading of currents of from 90 to 120 milliamperes. When, as is most commonly the case, the mean potential to be measured is 100 volts, the platinoid resistance is adjusted to make up, along with the fine copper wire solenoid (of which the resistance is about 60 ohms), a total resistance of 1,000 ohms. Thus, the direct reading of potential on scale is in volts.

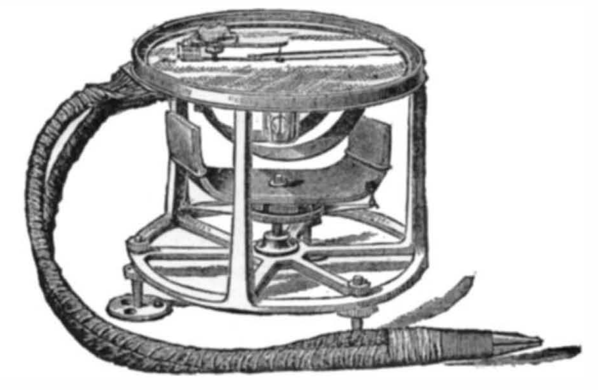
This instrument is founded on the principle that an oblate spheroid of soft iron, movable round a diameter, tends to turn its equatorial plane parallel to the lines of force in a uniform magnetic field. In the zero position the equatorial plane of the oblate is inclined about 45° to the lines of force of the solenoid, and torsion by the upper and lower parts of the bearing platinoid wire tends to turn it into a position perpendicular to the lines of force. This tendency is balanced by a stop against the needle when no current, or any current not exceeding 90 milliamperes, passes through the solenoid. When a current exceeding 90 milliamperes passes, the torsion couple is balanced by the couple due to the electro-magnetic force.

ADJUSTABLE MAGNETO-STATIC CURRENT METER.

This instrument has an advantage over the balance instruments, important for some practical purposes, of being available as an accurate direct reading current meter through a continuous range of from 1 to 90 or 100. Its disadvantages are that it is not available as an alternate current instrument, and that the magnetism of the steel directing magnet does not remain absolutely constant. With good quality of steel, a proper preliminary *ageing* of the magnet (by heating it several times in boiling water and cooling it again, and subjecting it to somewhat varied rough usage) brings it to a condition in which its magnetism may probably remain exceedingly nearly constant month after month and year after year. Still, it can never be relied upon as absolutely constant. It is therefore necessary to have some means of accurately retesting and readjusting the instrument at any time. This is always easily done with the utmost accuracy if one of the balance ampere meters is available as a standard.

When the instrument is used as a lamp counter, primary adjustment or readjustment, at any time, can be performed with great ease, without the aid of any other measuring instrument, by turning the screw platform which bears the adjusting magnet, so as to raise it or lower it until it is found that the deviation from zero produced by the current of any number of lights shows a corresponding number on the scale of the instrument. After each motion of the magnet the zero of course must be readjusted, which can be done either by throwing off all the lamps, or throwing the instrument out of circuit, and then turning the magnet till the needle points to zero. The lower screw must be screwed firmly up to pinch the upper screw when the adjustment is completed. If this is done firmly enough the magnet may at any time, without scruple, be turned round on its platform and brought back again, whether for setting the zero or for any other purpose, as it is only by turning the upper screw that the distance of the magnet from the needle can be altered.

The scale has 100 divisions, corresponding to equal differences of tangents of the angle between the magnetic axis of the needle and the electro-magnetic axis-vertical of the rings. The divisions may be numbered



MAGNETO-STATIC CURRENT METER.

from 0 to 100, but for many purposes it is convenient to number them from 30, 20, or 10, on the left, to zero, and from zero to 70, 80, or 90 on the right, because we thus have larger divisions in the neighborhood of the zero than when it is taken at the extreme left of the scale, and because it is sometimes convenient to measure small currents in the direction opposite to that of the currents ordinarily measured. For most purposes probably the numbering 10 left to zero and zero to 90 right will be found most convenient. With scales so numbered any number of lamps from 1 to 90 can be counted by integral numbers of scale divisions. Of course this is not possible to any great accuracy, because the lamps are not all rigorously equal, but the lamp counter serves the important practical purpose of showing at any time the exact number of lamps in use when less than 10 or 15, and nearly enough, for practical purposes, the exact number, however many there are. In private houses it is very useful as a check against some lamp or lamps being left accidentally alight in a cellar or safe room or other place where the fact of its being alight might escape observation for days or weeks together.

To count larger numbers of lamps up to 1,000 or more the instrument is made with smaller rings of more massive conductor. The same proportionate accuracy is attained as with the 100 lamp counter.—*Electrician.*

STUDIES ON DYNAMO ELECTRIC MACHINES.

In a dynamo electric machine there are two parts to be distinguished—the field magnet, the object of which is to produce a magnetic field as extensive and as intense as possible, and the winding of the armature, the object of which is to utilize the field as well as possible for the production of electric energy. Each of these parts may be studied separately, and this, perhaps, is the best way to get an idea of the advantages and drawbacks of the different systems.

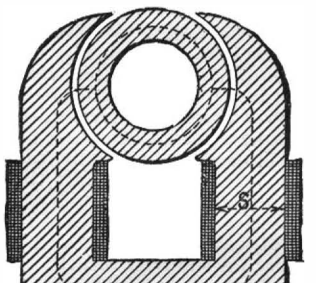


Fig. 1.

It may be admitted in a general way that in any well understood dynamo the energy created is proportional : (1) to the extent of the magnetic field, V ; (2) to the intensity, H, of such field ; (3) to the velocity, v, of the wires ; and (4) to the density, δ, of the current in the latter.

The more energetic the magnetic field is, the less will the pernicious reactions of the armature make themselves felt ; so that an endeavor is now made to produce as intense a field as possible, and the first

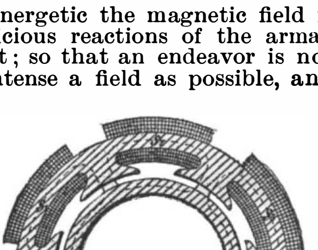


Fig. 2.

question that comes up is to know what are the best means to employ for this purpose, and how the magnet must be arranged in order that the expense of the first establishment shall be slight, and that the excitation shall cost as little as possible.

Electric science is now far enough advanced to allow us to obtain a sufficiently exact idea of the question.

The first remark to be made is that it is necessary to give the magnetic circuit of the field magnet everywhere a section sufficient for the number of lines of force that it is desired to pass into it.

FIG. 3.—ALTERNATING CURRENT GRAMME MACHINE.

If it be proposed to obtain a magnetic field of 5,000 C.G.S. units, for example, it will be necessary to give the iron of the electros and armature a section equal to at least a third of the surface of the magnetic field, otherwise the iron would come too near to saturation and possess too great a magnetic resistance.

The second remark concerns the energy necessary to keep up the magnetic field: We shall always expend less energy in producing a magnetic field of the extent, V, and intensity, H, by means of a single magnetic circuit (Fig. 1) than by means of multiple circuits, as in the case shown in Fig. 2. In these figures the magnetic circuits are shown by dotted lines.

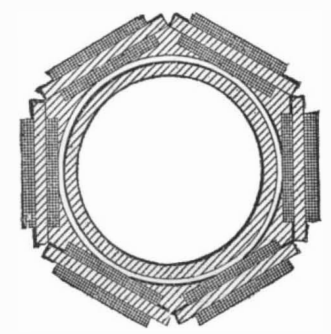


FIG. 4.—THURY MACHINE.

In fact, it is the air (between irons) that forms the principal resistance to the flux of the lines of force in the magnetic circuits of our machines. This interval remaining the same in the two figures, it will be necessary to have the same number of ampere revolutions for the excitation of the single magnetic circuit of Fig. 1 as for each of the circuits of Fig. 2; and it will be readily seen that, for the same surface of magnetic field, it will be necessary to employ more wire in the arrangement shown in Fig. 2 than in the one shown in Fig. 1, and that, consequently, it will be necessary to expend more energy for the excitation in the first case than in the second. A single magnetic circuit is therefore preferable from this point of view.

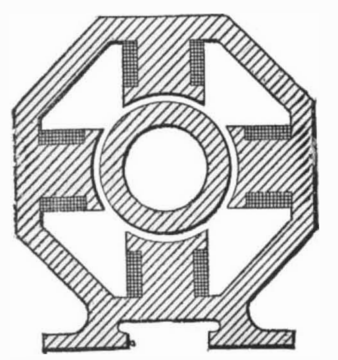


FIG. 5.—GRAMME MACHINE (1885).

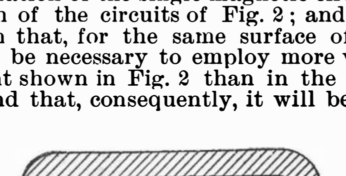


FIG. 6.—KENNEDY MACHINE.

The question changes aspect when we consider the weight of the iron. It will be seen, in fact, that although the extent of these fields remains the same, as well as the total section $S=s_1+s_2+s_3+s_4+s_5+s_6$, the multipolar machine (Fig. 2) will be much lighter.

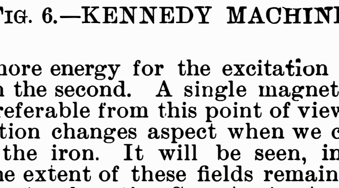


FIG. 7.—LAHMEYER MACHINE.

This consideration allows us to compare the respective advantages and disadvantages of bipolar and multipolar machines.

With equal power, multipolar machines can be rendered lighter, but the bipolar ones will give a better performance.

With the same extent of magnetic field and peripheric velocity of the wires, we may easily and economically give multipolar machines a wide ring diameter, and at the same time reduce the ring's length, which is something that cannot be rationally done with a bipolar machine. The former will, consequently, have a less angular velocity, and this is often very advantageous, especially when these machines are used as motors (receivers).

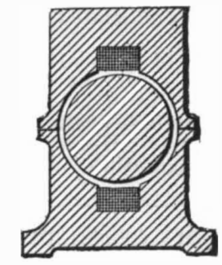


FIG. 8.—EICKEMEYER MACHINE.

On the contrary, the winding of the armature and the junction of the commutator bars will be more complicated in multipolar machines than in bipolar ones.

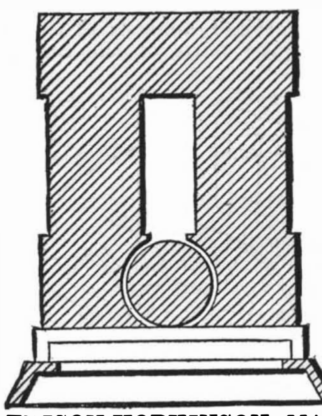


FIG. 9.—EDISON-HOPKINSON MACHINE.

In the accompanying engravings we have brought together a few of the best known or most characteristic machines, selected from among many others.

It will be remarked that a certain number of the best manufacturers, such as Weston, Crompton, and others, use a two-circuit arrangement in their bipolar machines. This is due to the fact that, beyond a certain power, the electric performance of well constructed machines becomes so high (95 to 97 per cent.) that it is no longer of any great importance if we lose a little more or a little less for the excitation of the electros. The reasons for symmetry, then, are of more importance than the small saving that we might make in the excitation, while this question is much more important for multipolar machines of mean power, of which the performance is, as a general thing, pretty bad.

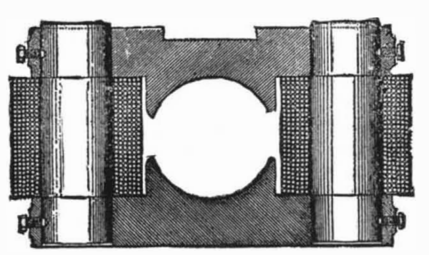


FIG. 10.—MATHER & PLATT MACHINE.

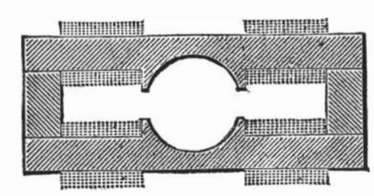


FIG. 11.—CROMPTON MACHINE.

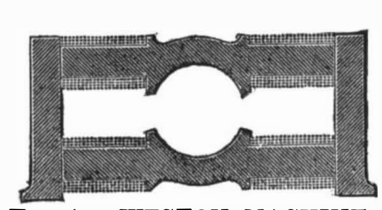


FIG. 12.—WESTON MACHINE.

Thus it is that the arrangement of the new Siemens & Halske machines, and of the old Gramme alternating current machine, with internal electro magnets, is preferable, as regards performance, to Thury's arrangement with consequent poles (Fig. 4), which, for the same number of poles, has double the number of magnetic circuits. The Gramme machine (Fig. 5) belongs likewise to the first category, in fact, the magnetic circuits dividing only outside of the exciting bobbins. But this arrangement of the field magnets is cumbersome. In recent times, several inventors have endeavored to envelop the bobbins of the electro magnets more or less completely with iron (Kennedy, Fig. 6, Lahmeyer, Fig. 7, Eickemeyer, Fig. 8, and Wenstrom), so as, on the one hand, to utilize the magnetic action of the spirals as much as possible, and, on the other, to lose as little as possible of the lines of force in the air.

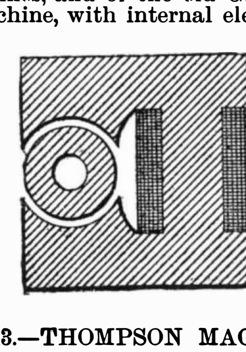


FIG. 13.—THOMPSON MACHINE.

In the Wenstrom, Hopkins, etc., machines, an endeavor has been made to create multipolar machines of a single magnetic circuit, that is to say, the polar pieces of a large electro magnet, instead of forming two poles, as in a bipolar machine, are divided into teeth that alternately engage with one another, and form, with respect to the armature, as many alternate poles, just as in a multipolar machine.—*La Lumiere Electrique.*

[THE NEUROLOGICAL REVIEW.]

GENIUS NOT A NEUROSIS.

By JAS. G. KIERNAN, M.D., Chicago, Ill.

CERTAIN alienists, notably Moreau de Tours, have claimed that genius, especially poetic genius, is a neurosis, and that the man of genius is but a

Poor lunatic who makes his moan,
And for a while beguiles his lookers-on.
He reasons well. His eyes their wildness lose;
But, if you hit the cause that hurts his brain,
His eyeballs roll, and he is mad again.

Nathaniel Lee, the periodical lunatic who wrote these lines, has very good reason for accepting this theory. Nor is Nathaniel Lee the only mad poet. Lucretius, Marlowe, Ben Jonson, Bunyan, Wycherley, Torquato Tasso, Moliere, Swift, Pope, Defoe, Rousseau, Goldsmith, Johnson, Savage, Cowper, Byron, Walter Scott, Coleridge, De Quincey, Rogers, Southey, Shelley, Emerson, Saxe, Poe, and Victor Hugo all suffered from insanity.

Poetry is an emotional outburst of a perception of similarities in unlike things. Hence, the "fine poetic frenzy" of the poet is not unlike the emotional exaltation of the insane. Many a matter-of-fact young man or woman in the emotional stages of insanity has composed respectable poetry, and lost this faculty on recovery. In periodical insanity, the appearance of poetry is often an indication for medical treatment. Rush had under care an insane woman, over whose songs "he hung with delight." Pinel has cited the case of a young girl who, during paroxysms of insanity, expressed herself in very harmonious verse, and lost this faculty on recovery. Van Swieten has had under observation a very similar case. Hammond reports the case of a rhyming clergyman.

The analogy is, however, of the most superficial kind; none of these lunatics was capable of a sustained poetic flight; nor do the cases bear out the theory. Lucretius' acute attack of insanity marred his poem, as will be obvious on comparing portions of Book III. of *De Rerum Natura* with the rest.

Marlowe's wild outbursts against society and religion, his delusions and persecutional visions, were of insane origin. But the insanity marred his genius. His "Jew of Malta" is a mass of tumid bombast compared with the "Merchant of Venice."

Ben Jonson's insanity arose from his gout, and marred much of his work. When most free from gout, his work is the best. His hallucinations of vision were those of gouty insanity.

Bunyan was paranoiac, in whom emotional perversion, and hallucinatory disturbance therefrom resulting, were in the foreground. He, as Spitzka has pointed out, made a nearly complete recovery, and not till then did his "Pilgrim's Progress" appear.

When Wycherley's mind gave way under debauchery, his work, when it did not consist of unconscious assimilations, was mere drivel. During Torquato Tasso's periodical attacks of insanity nothing poetic was produced.

Swift's middle-ear nerve disease caused insane suspicions and irritability. In his youth he was wild and erratic, and was rejected at first for his "B. A." degrees as "conspicuously deficient." His servitude to Sir William Temple held his insane tendencies in check by its rigid discipline. He marred his writings by the introduction of physically disgusting irrelevant topics. From his irritability resulted his cruelty to Stella. His insanity once fully developed, his creative powers vanished.

Moliere's epileptic insanity tinged his genial humor with sarcastic suspicion. His savage diatribes against physicians increased or waned as the number of fits decreased or increased.

Pope's malignancy, coarse language to women, egotism, suspicional delusions, mean conspiracies for notoriety, tricks on his dearest friends, were the outcome of an insanity which checked his intellect at the boyish stage. Pope was intellectually a hebephreniac all his life. His poetry was a "mere methodic art," and hence was the result of forces antagonistic to insanity. Defoe manifested insanity only as a result of age.

Rousseau, like Pope, was the victim of the unequal development of mind and body after boyhood, a hebephreniac. He manifested much the same suspicional delusions as Pope, on one occasion accusing David Hume of an attempt to murder him. He believed that enemies were leagued against him, and delighted in cheap notoriety while affecting to despise it, and manifested this very obtrusively. Hs was, in all his philosophy, the outcome of Locke. Had Locke never existed, there would never have been a Rousseau.

Goldsmith had a slight imbecility of judgment, which led to his inventively stupid deceptions of his mother, his "Uncle Contarine," and his incongruities with his surroundings. The "Deserted Village," "Vicar of Wakefield," "She Stoops to Conquer," were not the offspring of mental disease; but his "Animated Nature" displays his imbecility of judgment to a great degree, albeit it is concealed by a pellucid style. His mental defects were but a slight twist in the judgment, and a blunted moral sense.

That the sanity of Johnson, the great "Cham" of literature, should ever be doubted, will seem strange to the students of English literary history who remember the "Club," with its brilliant conversaziones. Macau-

lay has said Boswell, and not his own works, made Johnson immortal. Johnson's father suffered from a mental twist which tinged all his ideas with gloom, and made him the prey of imaginary disease. He fell under the sway of the established church, and the simple creed, "fear God and honor the king," repressed all religious emotionalism and the mental disturbances which result therefrom. This creed strengthened the checks on his emotions. Johnson himself was the born victim of nervous and other diseases. He suffered from hallucinations of hearing; he heard his mother, then many miles away, call him "Sam! Sam!" When he entered a doorway, he would suddenly whirl and twist about in strange gesticulations. He would often stop in the middle of the streets to go through this ceremonial. At a dinner party he once twisted off the shoe of a lady who sat next him in one of these performances. He was subject to lengthened periods of mental torpor, when he hardly knew what was going on around him. His "Rasselas" indicates that he, at times, suspected his own mental condition. Much of this "insanity of manner" served as a safety valve to work off the morbid force. The comfortable routine faith of the English church acted like spiritual laudanum on such a mind. That the keenness of his mind was blunted by the torpidity of disease is evident in his works. As Leslie Stephen remarks, had he "gone through the excitement of a religious conversion, he would probably have ended his days in a madhouse." His mental disease marred his genius, as cracks distort the reflecting powers of a mirror.

Savage had all the characteristics of the lunatic who is a reversion to the barbarian type of man, born in the midst of civilization with which he is unable to reconcile himself. His works, kept alive by Johnson, are not intellectually above the level of the "sweet singer of Podunk," or some similar locality, and their equals are daily thrown into the waste paper basket by the insane-hospital physician after his return from his daily visits to the scribbling insane. The genius in Savage was swamped by the insanity.

Cowper was subject to a periodical melancholy. His poetry composed under this influence was beneath mediocrity. Fortunately for Cowper, he fell under the influence of the religious quietists, and the soothing influence of their mild creed favorably affected him, so that "The Task" was the outcome of a period of sanity between the periodical attacks.

Byron came from a family in which insanity was rife. His desire of cheap notoriety, his obtrusiveness of his own affairs, his mendacity, his affectation of vices which he did not possess, show that he was, as Swinburne says, a "brilliant boy" whose intellectual development into manhood was checked. The insane tendency checked the full development of genius. In him the hebephreniac tinged with paranoia appears.

No clearer intellect ever made its appearance in the world of letters than that of Walter Scott. Not until his brain broke down under the mental strain of the failure of the book publishing speculation and the struggle to pay his debts, did the dead Byron appear at his window. There is no mental weakness in the "Lady of the Lake," nor in "Rob Roy;" but it appears in every page of "Count Robert of Paris," written when paretic dementia had seized him.

Southey and Rogers both fell victims to coarse brain disease, dementia, the distant outcome of apoplexy. When they became insane, their poetry ceased to appear.

Shelley was, like Cowper, a victim of periodical insanity. The insanity alternated with literary productiveness. When Shelley saw "the woman with eyes in the center of her breasts," he could not write poetry. When his delusions of persecution were present, no masterpieces made their appearance.

Coleridge was the prey of his own ideas, usually of outside suggestion, and for this reason his productions have a fragmentary character. He himself draws a pretty good picture of his mental state when he says: "Why need we talk of a fiery hell? If the will, which is the law of our nature, were withdrawn from our memory, fancy, understanding, and reason, no other hell could equal what we should then feel from the anarchy of our powers." De Quincey's mental condition resembled that of Coleridge; the weak wills of both produced their meconophagism.

The apoplexy which produced Emerson's insanity destroyed his genius. Poe, who resembles Swift in his liking for the physically disgusting, manifested this liking most strongly after recovery from periodical insanity, which, in him, took the form of drunkenness. He analyzed his own mental state in his sane periods, and from such an analysis sprang the "Fall of the House Usher." In one of Poe's insane periods he was dragged from one Baltimore polling place to another, and voted by ward workers. From the resulting exhaustion he died.

Saxe is the victim of melancholia, the consequence of "railroad spine." Victor Hugo was the least demonstrably insane member of an insane family. His brothers, sisters, several ancestors and collateral descendants were insane. He received a methodic training, and fell under the influence of the English dramatists. His insane tendencies were at once held in check, and afforded a safety valve. At times his insanity converts intended sublimity into drivel. There is much in his Les Miserables and L'Homme qui Rit that is at once weak and insane.

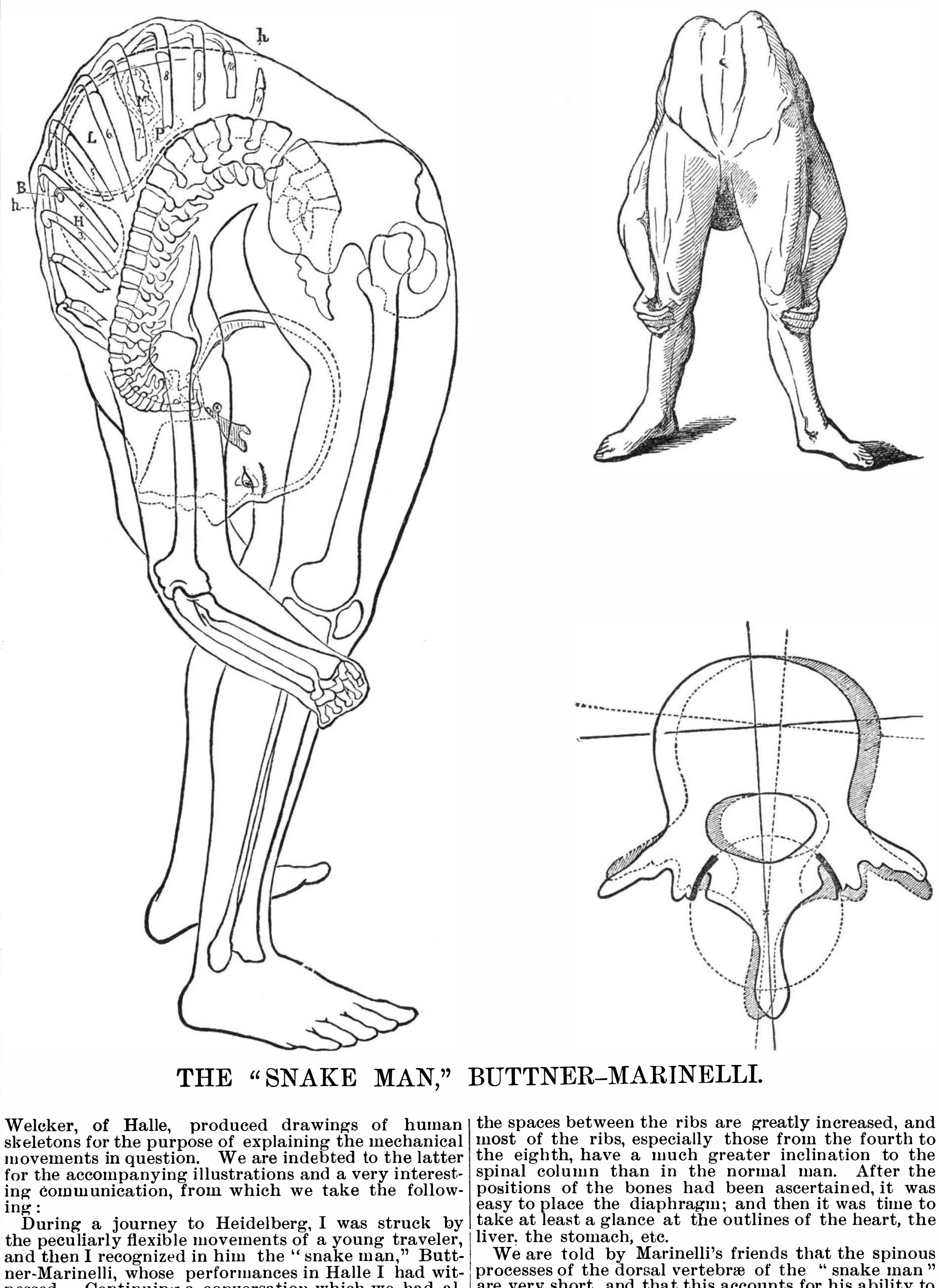
Genius is not a product of morbid mind. In the exceptional instances where the two co-exist the genius is evidence of a healthy conservative element struggling with the incubus of disease. Insanity may, in its emotional stages, touch the lips of a timid poet; but his song soon sinks beneath the disease. The best balanced poets have been the greatest. Shakespeare's works are evidence of a well balanced intellect. Nothing exists to impugn the sanity of Milton, Addison, Wordsworth, Tennyson, Klopstock, Goethe, Schiller, Burger, Filicaja, Camoens, Freiligrath, Longfellow, Dickens, Thackeray, Freytag, or of most of the stars of literature. The Elizabethan dramatists were keen psychologists, and the examination for insanity which Ben Jonson brings on the stage denotes a rare knowledge of mental phenomena. Sophocles wrote his tragedies at a great age, and his sons called him into court to have him placed under guardianship as a dement. He refuted the imputation of his mental condition by reciting "Œdipus Colonus," which he had just composed, to his judges, who thereupon pronounced him mentally competent.

The doctrine that poetic genius is an offspring of disease is a dangerous one; it deprives poetry of its elevating character, and excuses the excesses of the poet on the ground of irresponsibility, at once hardening the community and degrading literature, and such a doctrine should be enunciated only on the most well sustained basis.

The subtile chain of associating power which constitutes genius in its highest and best sense differs very decidedly from the disjointed condition existing in paranoia. The highest poetic genius is closely akin to the highest scientific. Huxley's phrase, "the scientific use of the imagination," was the expression of a profound truth.

THE "SNAKE MAN," BUTTNER-MARINELLI.

ANY ONE who has seen the remarkable feats of the contortionist Buttner-Marinelli will naturally ask whether the construction of his frame is normal, or whether this unusual backward bending of the spinal column is not allowed by some abnormal construction of his bones. This question is extremely interesting to all students of the moving apparatus of the human body, and men of science immediately began to investigate the matter. Dr. Hans Virchow, of Berlin, undertook a thorough analysis of this bending and displacement of the parts of the frame; and Prof. Welcker, of Halle, produced drawings of human skeletons for the purpose of explaining the mechanical movements in question. We are indebted to the latter for the accompanying illustrations and a very interesting communication, from which we take the following:



THE "SNAKE MAN," BUTTNER-MARINELLI.

During a journey to Heidelberg, I was struck by the peculiarly flexible movements of a young traveler, and then I recognized in him the "snake man," Buttner-Marinelli, whose performances in Halle I had witnessed. Continuing a conversation which we had already begun, I asked him if he had any photographs of his most remarkable postures, and as he answered in the affirmative, begged him to send me some, for I intended to make drawings of the human skeleton bent backward. He afterward sent me fourteen excellent photographs.

In Marinelli's performances, he assumes two principal positions; in one his trunk is arched, the spinal column being bent backward, and in the other it is twisted spirally. He forms the arch perfectly, for when he is standing with his legs separated, he bends backward and takes hold of his knees, pressing the top of his head against his thighs.

I decided that the easiest way to proceed with my investigations would be to saw the vertebræ of the skeleton that I used in half and lay them on a life-sized copy of the original photograph, which I did—with the assistance of Dr. Eisler. The positions of the dorsal vertebræ gave me the most trouble. Did Marinelli overcome the backward curve of the same (kyphosis) entirely, or was there some of the front concavity left? From two of the photographs it might be supposed that with Marinelli there was a slight front concavity of the dorsal vertebræ Remembering the saying of Schmidt von der Launitz, that the thorax of a person bending backward throws the same shadow as that of a person bending forward, I preferred to do too little rather than too much in regard to this point when making my drawings, and therefore left a slight kyphosis of the dorsal vertebræ. That this treatment of the subject is, at least, very nearly correct, is shown by the positions of the ribs, and, more particularly, the cartilage of the ribs.

It is very seldom that the walls of the lower breast and upper abdomen can endure a backward bending, because the parts in the front portion of the body must be extended and must give backward, while the parts at the back are crowded together. When Marinelli bends back, a deep furrow is formed in the middle of the covering of the abdomen, but the side edge of the thorax cavity is shown in profile, as in the accompanying cut, in which the broken line, *h*, *h*, represents the middle line of the lower chest and upper part of the abdomen, and B indicates the nipples. The furrow, or hollow, which reaches nearly to the nipples, is shown in the front view. As this position threw the cartilage of the lower ribs into profile, forming a waving line, the separate ribs could easily be traced in the original photograph. This was a great help in placing the vertebræ. In this backward bending of Marinelli, the spaces between the ribs are greatly increased, and most of the ribs, especially those from the fourth to the eighth, have a much greater inclination to the spinal column than in the normal man. After the positions of the bones had been ascertained, it was easy to place the diaphragm; and then it was time to take at least a glance at the outlines of the heart, the liver, the stomach, etc.

We are told by Marinelli's friends that the spinous processes of the dorsal vertebræ of the "snake man" are very short, and that this accounts for his ability to assume his remarkable postures; but I did not find that these processes of the spinal columns used by me were any impediment. On the contrary, they would have permitted a further bending backward.

Before me lie two photographs, showing the longitudinal twisting of the trunk. In one of these Marinelli rests his feet and hands on the ground, but while his face is turned toward the ground, his breast is toward the left, and the lower part of his body and his knees are turned upward. From the chin to the lower lumbar region the trunk is drawn around the middle line of the body in a spiral curve. The second photograph shows the body in an upright position, but the trunk is turned so that the hands do not touch the knees, but the calves, and the head is turned so that the face is where the back of the head would naturally be. Of course, in this combination of the arch and twisting, the last-named position of the body is not attained to such a marked degree as the first-named, but, on the other hand, the furrow referred to above extends remarkably high. As the torsion of the spinal column occurs chiefly in the lumbar region, it is evident

that the vertebræ yield so as to be pushed together horizontally, as shown in the smallest cut.

In an interesting paper by Virchow, we find the statement that, when Marinelli stands erect, there is no kyphosis of the back, but that when he bends very far forward, a slight kyphosis is noticeable. At a later examination, Virchow found a slight convexity toward the back. Even after considerable observation, I would not like to say, without having examined Marinelli's back with a measure and plumb, that his back is as hollow as the above mentioned statement would lead one to suppose.—*Illustrirte Zeitung.*

SOME OF THE CONDITIONS AFFECTING THE DISTRIBUTION OF MICRO-ORGANISMS IN THE ATMOSPHERE.*

By PERCY F. FRANKLAND, Ph.D., B.Sc (London), F.C.S., F.I.C., Assoc. Royal School of Mines.

THAT the air we breathe is more or less laden with living organisms is a fact which is far from acceptable to most persons, and yet it would require but little persuasion to convince the majority of mankind that air without organisms would be undesirable indeed; for without one micro-organism at least, which is very widely distributed in the air, we should have to forego those numerous, complex, and much appreciated pleasures which are derived from the consumption of alcohol in its various forms. How many would vote the earth flat and stale but for the products which are alone elaborated by *yeast*, which was the first micro-organism to receive attention, and which, in spite of the many powerfully organized endeavors to undermine its position, is likely also to be the last to absorb the interest of man.

But there are other micro-organisms in the air besides yeast, and it is the firm conviction that many zymotic diseases are propagated by means of air-carried microbes, that renders the investigation of the subject of aerial micro-organisms peculiarly interesting and attractive.

Passing over a number of isolated observations by Leeuwenhoek, Ehrenberg, and Gaultier de Claubry, the systematic examination of the aerial microbia commences with those marvelous discoveries with which the name of Pasteur is so inseparably connected, and with which the latter half of the nineteenth century will forever be associated.

These now classical researches of Pasteur's on the presence of micro-organisms in the atmosphere were undertaken in connection with the fierce controversy which raged, some thirty years ago, on the "*Spontaneous Generation of Life.*"

As most of you are doubtless aware, it was contended by the teachers of this doctrine that the presence of the smallest particle of air was sufficient to determine the generation of low forms of life in certain highly putrescible substances, such as milk, blood, infusions of meat, and the like. The opponents of this doctrine, marshaled by M. Pasteur, contended, on the other hand, that it was not the air, but certain living germs suspended in the air, which, gaining access to these putrescible materials, gave rise to those growths which make their appearance in them.

"Were this the case," replied his antagonists, the preachers of spontaneous generation, "these aerial germs would give rise to a fog as opaque and impenetrable as steel." But Pasteur's convictions were not to be shaken by dogmatic and baseless assertions of this kind, and he therefore undertook to prove his case by experiments so clinching and unanswerable that they could leave no shadow of doubt in any unbiased mind.

PASTEUR'S EXPERIMENTS.

The methods by which Pasteur not only revealed the presence of micro-organisms in the atmosphere, but, at the same time, roughly mapped out their distribution, are so striking in their beautiful simplicity, that I must, at the risk of being charged with telling an old tale, refer to them in more detail than might appear warrantable.

Pasteur's Apparatus.—The apparatus employed by Pasteur for this purpose consisted of a number of small flasks, such as you see here. Into these flasks, which were about one-quarter liter capacity, was introduced a small quantity of what is known as a *cultivating medium, i. e.*, a material in which these lower forms of life are capable of flourishing and multiplying abundantly. The cultivating medium employed in this case was clear broth, which forms an excellent nourishing material for the greater number of known micro-organisms. The necks of these flasks were then drawn out to a fine aperture, and the contents heated to boiling for some time, with the double object of *sterilizing*, or destroying, any living matter in the culture-medium on the one hand, and, on the other, of expelling the air from the flask. The open extremity of the flask was then sealed with the blowpipe, while steam was still issuing from the mouth. Pasteur found that the cultivating material in flasks thus prepared remained sterile for an indefinite period of time, and by this and numerous other experiments, into which I cannot enter here, conclusively disproved the theory of the spontaneous generation of these lower forms of life.

With a collection of flasks of this kind, Pasteur then explored the atmosphere of a number of different places. For, by breaking off the drawn-out extremities of the flasks in any given place, the vacuum inside the flask is immediately filled with a sample of the air in question, with all that it holds in suspension. The broken point is then immediately resealed before the blowpipe, and on preserving the flask at a suitable temperature for a few weeks, the presence of any living organism which has gained access along with the air will become revealed by its growth in the broth, rendering the latter turbid.

Now Pasteur exposed—

20 flasks in the open country of Arbois.
20 more on the lower heights of the Jura Mountains.
20 more at the Montanvert, close to the Mer de Glace, at a height of upward of 6,000 feet.

These three series of samples were deposited by Pasteur in the bureau of the Academy of Sciences, in the month of November, 1860. The result, which was awaited with the utmost interest by the numerous *savants* who had taken part in the previous discussions, was as follows:

Of the 20 flasks opened in Arbois, 8 developed living organisms.
Of the 20 flasks opened on the Jura, 5 became affected.
While of the 20 flasks opened on the Montanvert, only 1 broke down.

These results speak for themselves, and require no comment.

TYNDALL'S EXPERIMENTS.

These investigations were not, however, confined to France, for in this country the subject was, as is well known, pursued by Professor Burdon Sanderson, Sir Joseph Lister, Dr. Tyndall, and Professor Lankester, to all of whom we are indebted for so much of our knowledge concerning the conditions of life of these lower organisms. It is, however, with Dr. Tyndall's researches on aerial micro-organisms that we are more particularly concerned this evening. Tyndall's experiments were more especially directed toward tracing the connection between some of the optical properties of air and the presence of living organisms in it.

As is well known, when a powerful beam of light is passed through the air of an ordinary room, the path of the beam is rendered visible by the illumination of a vast multitude of floating particles. Now, Tyndall found that if the air in an inclosed chamber be allowed to remain at rest for some time, and a beam of light is then passed through the chamber, its path is no longer visible, the air within the chamber being free from suspended particles capable of reflecting and dispersing the light of the beam. He further showed that this "moteless air," as he called it, was incapable of causing alteration in boiled broth and other cultivating media, or, in short, that the moteless air was sterile or free from micro-organisms.

The great importance of these experiments lies in the conclusive demonstration which they yield of the comparatively short time which is required for suspended micro-organisms to subside in calm air, to which point we shall have occasion to refer again subsequently.

MIQUEL AND FREUDENREICH'S EXPERIMENTS.

We must now pass on to those endeavors which have been made to demonstrate the actual number of living micro-organisms present *in a given volume of air*—attempts, in fact, to raise the examination of air for micro-organisms from a *qualitative* to a *quantitative* one.

As we have noticed, in Pasteur's experiments already a certain indication was obtained of the relative abundance of micro-organisms in the air of different places, but these experiments made no pretensions to indicating the actual number of organisms present in a given volume of air. Pasteur's results simply show that there were less organisms in a given volume of air collected on the Montanvert than in the same volume of air collected at a lower altitude, but they make no claim to determining the actual number of organisms in a cubic foot or any other given volume of the air of any of the places referred to.

The experiments of Miquel and Freudenreich, however, lay claim to revealing, with more or less accuracy, the actual number of organisms present in a given volume of air, and we must now examine the basis upon which the claim of these investigators rests.

The principal method which these experimenters have devised for examining the air for micro-organisms consists in aspirating a certain volume of air through a small plug of glass wool, in passing through which the suspended matter, including any micro-organisms, is arrested. The plug of glass wool is then thoroughly mixed with a certain volume of sterilized water. The mixture thus obtained is then subdivided into such a number of equal parts that each part shall contain not more than one organism. Each of these subdivisions is then introduced into a tube or flask containing sterile broth. These tubes or flasks are then preserved at a suitable temperature, and any that have received a living organism will, in course of time, exhibit the fact by suffering visible alteration. Thus, supposing the plug through which 100 liters of air was drawn was mixed with 50 cubic centimeters of water, and a series of 50 tubes of broth were then each inoculated with 1 cubic centimeter of this mixture, and if then on keeping these 50 tubes at a suitable temperature it was found that only 40 of them suffered alteration, it would be concluded by Miquel and Freudenreich that only 40 organisms were present in the 50 cubic centimeters of water distributed among the 50 tubes, or, in other words, that the 100 liters of air contained 40 living organisms.

This method, which is extremely ingenious, and which is, perhaps, as perfect as a method in which a liquid cultivating medium is employed can be, still labors under defects which at the present time are altogether inadmissible.

The grave defect of this process consists in the difficulty of mixing and equally distributing the micro-organisms collected on the plug of glass wool. Thus, in the first place, if the mixture is not sufficiently subdivided, or, in other words, if the whole of the tubes into which the subdivided mixture is inoculated become affected, there is obviously no possibility of estimating the number of organisms present, for there is no evidence as to whether each tube succumbed to the presence of a single organism or to the presence of several. In this case the experiment is entirely lost, and all the care and trouble expended in its execution wasted.

But, even if the experiment is successful, and only a part of the inoculated tubes become affected, it is obvious that the deductions made from the result are not necessarily true, for it is only an assumption that each of the tubes affected has become so from the introduction of a single organism. As is well known to all who have practical experience in these matters, it is frequently quite impossible to secure an even distribution of organisms in a liquid containing suspended matter, such as the glass wool in the present instance. There is, in fact, no guarantee that the affected tubes have not succumbed in each case to more than one organism, and that, consequently, the subsequent calculation as to the number of microbes in the air operated on is not involved in serious error.

By means of this process, however, Miquel and Freudenreich have carried out a very large number of experiments on the presence of micro-organisms in the atmosphere, and the results are doubtless fairly comparable *inter se.*

SOLID CULTIVATING MEDIA.

The enormous progress which has, during the last ten years, been made in the study of micro-organisms is undoubtedly due to the far greater facilities which are now afforded by the beautiful methods of cultivation which have been so prominently brought before the scientific world by the masterly researches of Robert Koch. As might be anticipated, these methods of investigation, which enable all studies in connection with micro-organisms to be carried on with an exactitude and rapidity which was quite beyond the reach of the older observers, have also entirely altered the problem of approaching the micro-organisms present in the atmosphere.

The fundamental principles underlying the modern methods of bacteriological study are the substitution of solid for liquid cultivating media and the isolation of micro-organisms by plate cultivation.

The first adaptation of these new methods to the investigation of the micro-organisms of the air was made by Koch, who exposed dishes containing sterile solid cultivating material to the air, the organisms falling upon which subsequently gave rise, by their growth and multiplication, to visible colonies often possessing characteristic appearances. If the dishes are exposed to the air for a suitable length of time, the colonies resulting from the deposited organisms are sufficiently distant from each other to prevent their mutual interference. The number of these colonies can be readily counted, and the organisms belonging to each colony separately studied.

The number of colonies on dishes thus exposed gives no clew as to the number of micro-organisms present in a given volume of air, but only as to the number of organisms falling on a given surface in a given length of time. There exists, however, no better method than this for simply collecting organisms from the air, as in this manner pure cultivations of the various aerial microbes are obtained with the greatest facility. The exposure of such surfaces of solid culture materials at once added a very important point to our knowledge concerning the occurrence of micro-organisms in the air, for it was found that the colonies developing on surfaces are almost invariably pure cultivations—*i. e.*, the individual organisms constituting each particular colony are all of the same kind—thus clearly showing that the different varieties of organisms present in the air are separated from each other, and do not occur adhering together.

HESSE'S METHOD.

The solid cultivating media were first adapted by Hesse to determining the number of micro-organisms in a given volume of air. Hesse made the very remarkable discovery that, if air is slowly drawn through tubes of wide diameter, practically the whole of the micro-organisms suspended in the air are deposited within a very short distance, thus confirming and extending the observations which had been previously made by Tyndall in the case of his closed chambers.

In order to turn this remarkable gravitating property of aerial micro-organisms to account, Hesse constructed tubes, of about 3 ft. in length and 1½ in. in diameter. These tubes were internally coated with a solid layer of sterile gelatine-peptone. Protected by means of an India-rubber cap at one end, and a cork with a glass tube plugged with cotton wool at the other, the internal coating of gelatine remains unaltered for an indefinite period of time; but when the tube is to be used, the India-rubber cap is removed, and an aspirator attached to the glass tube at the other extremity, by means of which a slow current of air—about one liter in two to three minutes—is drawn through the tube.

The number of liters aspirated depends upon the comparative richness or poverty in microbes which experience leads one to anticipate that the air under examination will possess. For if there are only few organisms in the air, it is desirable to aspirate a considerable volume, perhaps twenty liters or more, while if the air is highly charged with microbes, a smaller volume must be taken, otherwise the resulting colonies in the tube will be so densely packed that they may interfere with each other.

After a definite volume of air has been drawn through the tube, the cap is replaced, and the tube kept at a suitable temperature for several days. On then inspecting the tube, it will be found to present a highly interesting appearance. The inside of the tube contains a number of colonies, each resulting from an organism which was deposited on the surface of the gelatine during the aspiration of the air.

Two highly characteristic points with regard to the distribution of these colonies at once strike the observer.

In the first place, the colonies are not found dispersed all over the tube, but are wholly confined to the bottom of the tube, the upper part being generally entirely free from colonies.

In the second place, it will be seen that the colonies are not by any means uniformly distributed over the bottom of the tube, but that they are more or less crowded together toward the front end of the tube, while the latter half is generally almost entirely free from colonies altogether.

As regards the nature of the colonies, they are, as in the case of those on the gelatine dishes already referred to, pure cultivations often possessed of characteristic appearances, sufficiently characteristic, at any rate, to enable the observer at once to discriminate between mould colonies and colonies of other micro-organisms.

A little closer attention to the contents of the tube generally shows a very remarkable arrangement of the mould colonies as distinguished from the bacterial colonies; for the mould colonies will be found, on the whole, further from the front end of the tube than the bacterial colonies, the extreme colony being almost invariably a mould, often very considerably further down the tube than the last bacterial colony.

Thus the examination of air by Hesse's method brings to light certain very important facts concerning the aerial micro-organisms; first, their rapid gravitation in comparatively still air, and, secondly, the more rapid gravitation of the bacterial organisms than of the mould organisms.

* A lecture recently delivered before the Society of Arts, London. From the Journal of the Society.

As a means of determining the number of micro-organisms in air, Hesse's apparatus is far more convenient than the method of Miquel and Freudenreich, which I have already described; it is, moreover, free from the objections which I have pointed out in connection with Miquel's process. On this account I availed myself of Hesse's method in making experiments on the distribution of micro-organisms in air.

To some of the results of these experiments I would now draw your attention. In studying the distribution of micro-organisms in air, I selected, as both a suitable and convenient spot for my central observatory, the roof of the Science Schools at South Kensington. This position is well fitted for observations of this kind, being sixty to seventy feet above the ground, and thus removed from local and accidental influences. A number of experiments were made here with the view of ascertaining the influence of season and atmospheric conditions generally on the abundance of aerial micro-organisms. These experiments, which were extended over the whole of the past year, are summarized in the following table and in the diagram on this page:

Roof of Science Schools (*South Kensington*).

1886.	Average number of colonies obtained from 10 liters of air (Hesse's method).
January	4
March	26
May	31
June	54
July	63
August	105
September	43
October	35
November	13
December	20

EXPERIMENTS ON THE DISTRIBUTION OF MICRO-ORGANISMS AT DIFFERENT ALTITUDES.

I have also made experiments with the view of ascertaining the relative abundance of micro-organisms at different altitudes in towns. These comparisons were effected by collecting samples of air at different elevations, on the spire of Norwich Cathedral, on the dome of St. Paul's, in London, and on Primrose Hill. The results of these experiments are exhibited in the accompanying diagram:

Place of experiment.	No. of organisms found in 10 liters of air.
Primrose Hill, May 19, 1886.	
Top	9
Bottom	24
Norwich Cathedral Spire, April 26, 1886.	
Top (300 ft.)	7
Tower (180 ft.)	9
Bottom (ground)	18
St. Paul's Cathedral, May 26, 1886.	
Golden gallery	11
Stone	34
Churchyard	70

EXPERIMENTS ON THE DISTRIBUTION OF MICRO-ORGANISMS IN COUNTRY PLACES.

In a number of experiments made in the country, principally at Reigate and in Norwich, a very appreciably smaller number of micro-organisms was observed than in the case of the air in London. Moreover, the more remote the place is from human habitations, and from the frequented thoroughfares of traffic, the dust of which is always rich in refuse organic matters, the freer does the air become from suspended microbes. Thus I found the air of an extensive heath near Norwich, and that of the Chalk Downs, in Surrey, exceedingly free from micro-organisms, while the air of gardens contained considerably more. Thus:

Place of experiment.	No. of organisms found in 10 liters of air.
Reigate Hill, Feb. 7, 1886	2
" May 23, 1886	13
Heath, near Norwich, April 23, 1886	7
" " April 27, 1886	5
Garden at Reigate, May 23, 1886	25
Garden near Norwich, April 28, 1886	31

EXPERIMENTS ON THE DISTRIBUTION OF MICRO-ORGANISMS IN OPEN PLACES IN LONDON.

It is particularly interesting to compare the number of micro-organisms found in country air with that found in the air of parks within London. For this purpose I have made some experiments in Hyde Park, in Kensington Gardens, and on Primrose Hill. These experiments show that, although the park air generally contains fewer micro-organisms than the air even on the roof of the Science Schools, and consequently much less than in the streets below, yet the number exceeds that in the country air. The experiments in the parks were made on large surfaces of grass, from which practically no dust could be blown about, so that the microbes found are doubtless those which have been carried by the wind from the surrounding thoroughfares.

Place of experiment.	No. of organisms found in 10 liters of air.
Kensington Gardens, April 1, 1886	13
Hyde Park, May 18, 1886	43
" June 7, 1886	18
Roof of Science Schools, June 7, 1886	62
Exhibition road, June 7, 1886	94
" " June 8, 1886	554
" " " "	309
" " June 10, 1886	18

MICRO-ORGANISMS IN SEA AIR.

In striking contrast to the number of micro-organisms found in the various places referred to above, is the number found in air at sea. I have not myself had an opportunity of making any experiments at sea, but recently some examinations of sea air have been made by Dr. Fischer, a surgeon in the German navy, and as he has used substantially the same methods as those which I have described, his results may be fairly regarded as comparative. Dr. Fischer's experiments may be thus summarized:

I.—14 experiments with an average of 113 liters of air contained no organisms.

II.—5 experiments with an average of 80 liters of air contained one organism.

III.—2 experiments with an average of 110 liters of air contained 2 organisms.

IV.—3 experiments with an average of 146 liters of air contained 3 organisms.

V.—6 experiments with an average of 62 liters of air contained 4-13 organisms.

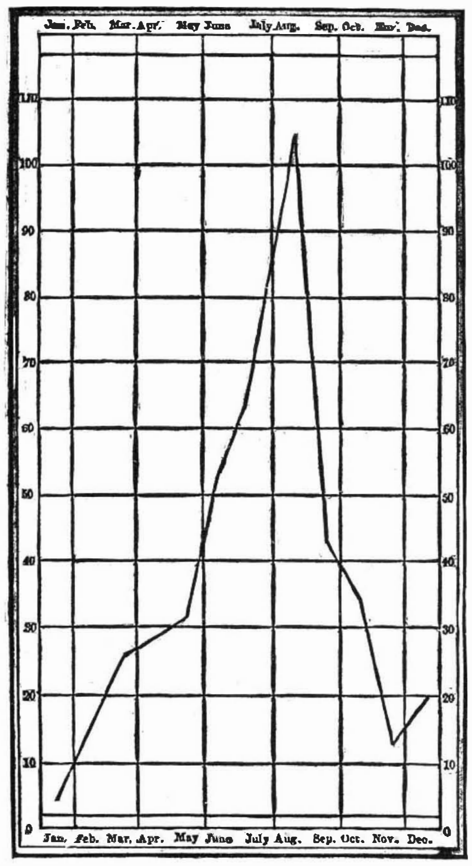
They may be more instructively classified, however, by taking into consideration the distance from the nearest land at the time of the observations, thus:

Maximum distance from land in sea miles, 90; 1 organism to 26 liters.

Minimum distance from land in sea miles, 120; 1 organism to 93 liters.

Moreover, out of 12 experiments, made at a minimum distance of 120 sea miles from land, in 11 the air was absolutely germ free, and in the remaining 1 only a single organism was found; while out of 12 experiments made at a maximum distance of 90 sea miles from land, in 7 cases organisms were demonstrable, and in only 5 cases not demonstrable. In 3 of these latter 5 cases, however, although the land actually nearest the ship was less than 90 miles, the nearest land in the direction from which the wind was coming was in two cases upward of 500 miles, and in one case 200 miles. In the other two the land was, in one case, 60 miles, and in one case only 8 miles distant, but in this case the land in question was only a small, slightly cultivated, and thinly populated island.

This clearly demonstrates, what we should have been led from *a priori* considerations to anticipate, that the principal factor is the distance from land in the direction from which the wind is proceeding. It would further appear that the maximum distance to which, under ordinary circumstances, micro-organisms can be transported across the sea lies between 70 and 120 sea miles, and that beyond this distance they are almost invariably absent.



CURVE SHOWING THE AVERAGE NUMBER OF MICRO-ORGANISMS IN TEN LITERS OF AIR.

Of particular interest in these experiments is the very distinct manner in which they show that the micro-organisms which are abundantly present in sea water are not communicated to the air, excepting in the closest proximity to the surface, even when the ocean is much disturbed.

MICRO-ORGANISMS IN THE AIR OF BUILDINGS.

It is obviously of interest also to ascertain whether the air which we breathe in our houses, and in inclosed spaces generally, is more or less charged with organic life than that which we meet with in the open. As the greater part of our life, in this country at any rate, is spent within doors—in dwelling houses, in assembly rooms, in offices, in laboratories, in railway carriages, and the like—it is only natural that we should be particularly inquisitive as to where and under what conditions in these various confined places we are likely to encounter the most living matter in the atmosphere.

In the following table I have collected the results of some of the experiments which I have made in this direction:

Place of experiment.	No. of organisms found in 10 liters of air.
Chemical Laboratory:	
Jan. 13, 1886	13
Oct. 15, "	30
" 16, "	14
" 27, "	32
Nov. 12, "	8
Kensington Museum:	
Friday, May 14, 1886	18
Saturday " 15, "	73
Natural History Museum:	
May 21, 1886 (a.m.)	50
" (p.m.)	70
June 14, 1886 (Whit Monday)	280
" "	267
Burlington House (Royal Society):	
June 9, 1886 (19·5° C.)	326
" (22·0° C.)	432
" 10, 1886 (17·0° C.)	130
Consumption Hospital, Brompton:	
May 21, 1886	43
"	130
"	42
June 1, 1886	19
"	34

ORGANISMS FALLING ON A GIVEN HORIZONTAL SURFACE IN UNIT OF TIME.

In order to obtain an idea of the number of microbes which may, under favorable circumstances, become suspended in the air, I have made some experiments in places where I considered it probable that there would be a microbial population even denser than that in any of the previous cases to which I have referred. Owing, however, to my not having the necessary apparatus available at the time, I was only able to make rough tests as to the number of micro-organisms falling upon a given horizontal surface in a given time. As, however, I have made similar tests in the case of nearly all the experiments previously alluded to, I am able to make use of them by way of comparison.

Thus the number of micro-organisms falling on a horizontal square foot of surface in one minute was as follows in the case of some of the experiments which we have already disscussed:

Place.	Number of micro-organisms falling on 1 sq. ft. in 1 minute.
Chemical Laboratory (4 experiments).	15
Kensington Museum (2 experiments)	54
Natural History Museum (2 experiments)	196
Natural History Museum, Whit Monday (2 experiments)	1,662
Burlington House (3 experiments)	222
Brompton Hospital (5 experiments)	54

We will now compare with the above the two cases to which I wish to draw your attention.

The first is that of a railway carriage (third class) on a journey from Norwich to London. Soon after leaving Norwich I tested the air; there were at the time four persons in the carriage, one window was closed, the other open, and the experiment was made near the open window. I found that under these conditions 395 organisms were falling on the square foot in one minute. On reaching Cambridge, the carriage was taken possession of by a number of men returning from Newmarket races. The carriage remained quite full (ten persons) to London. About half way between Cambridge and London I made a second experiment, one window being shut, and the other was only open four inches at the top. The air was tested near the closed window, with the result that no less than 3,120 organisms were found to be falling on the square foot in one minute.

On another occasion I made an experiment in a barn in which flail thrashing was going on. The atmosphere was visibly laden with dust, and on testing it with a gelatine dish, I found that upward of 8,000 organisms were falling on the square foot in one minute.

It would probably be difficult to find a place in which the number of suspended microbes was greater than this, the great abundance of bacterial life in the material under treatment, the dryness of the latter, and the violent commotion occasioned by the thrashing being all highly conducive to the distribution of an enormous multitude of micro-organisms throughout the air.

LATER IMPROVEMENTS IN APPARATUS AND METHODS.

A lengthened experience with Hesse's method of determining the number of micro-organisms in air convinced me that, although the method possesses many good qualities, it is by no means perfect, and that it has, in fact, many very serious defects, more especially when it is used in outdoor experiments. The fundamental defect in the process is that when the apparatus is used in a disturbed atmosphere, the results are liable to become seriously affected by aerial currents. Thus, if Hesse's tubes be exposed *without drawing any air through them*, a number of organisms gain access to the tube notwithstanding, and the number of these accessory organisms is dependent upon the strength and direction of the air currents during the experiment.

In all my experiments with Hesse's apparatus, I have endeavored to place the tube at an angle of 135° from the direction of the wind, so as to avoid a current of air entering the open end of the tube, but in several cases I have had to reject experiments in consequence of a sudden alteration in the direction of the wind, and in the open air there are almost invariably minor fluctuations.

In consequence of this and several other defects, into which I need not here enter, I have devised a method in which I have endeavored to overcome these objections. In this method, a definite volume of air is drawn, by means of an air pump, through a short piece of glass tubing containing two small porous plugs placed one in front of the other. Of these two plugs, the first is constructed of glass wool only, while the second is formed of glass wool and glass or sugar powder. The object of this arrangement is that the second plug, through which the aspirated air has to pass, shall offer more resistance than the first, and, consequently, if the second plug is found to be free from microbes, it may safely be assumed that the first plug has been sufficiently obstructive to the micro-organisms in the air passing through, and that they have all been retained by it.

Each plug is then transferred, with special precautions, to a small flask containing a small quantity of sterile melted nutrient gelatine; with the latter the plug is now agitated, so as to cause the rapid disintegration of the plug, and the liquid gelatine, throughout which the *debris* of the plug and its contained microbia are distributed, is then evenly spread over the interior of the flask, and there congealed by rotating

the flask in a stream of cold water. The flask is then maintained at a suitable temperature, and in due time the colonies, each resulting from one of the original micro-organisms deposited on the plug, make their appearance, and can be counted or further examined. That this process is, in contrast to Hesse's, practically independent of aerial currents, is seen from the fact that, if plugged tubes are simultaneously exposed without drawing air through them, the plugs are almost invariably free from organisms.

When air is simultaneously examined by Hesse's method and the "flask method" which I have just described, we find that indoors, and in an undisturbed atmosphere generally, the results are in very close accord, but that in a wind, more especially when the direction of the latter is variable, the results obtained by Hesse's method are considerably higher than those obtained with the flask method, the difference being obviously due to the defect which I have already pointed out in Hesse's method.

The practical identity of the results obtained under favorable circumstances by these two methods throws light upon the state of aggregation in which micro-organisms exist in the atmosphere. Thus, the colonies in Hesse's tubes are not necessarily each derived from a single microbe, but each colony might just as well be the result of a mass of organisms, which might be numbered by tens, hundreds, or even thousands. Each such aggregate, falling upon the surface of the gelatine in a Hesse's tube, would give rise to perfectly similar colonies. The colonies in the flasks, however, are obtained in a very different manner. Here any masses of organisms would have become more or less broken up in the precess of agitation to which the plugs are exposed in mixing with the gelatine. Consequently, if such masses existed, the number of colonies to which they would give rise in the flasks would exceed, and possibly to an enormous extent, those obtained in the Hesse's tubes; but, as we have seen, such is not the case, the number of colonies in the flasks being practically identical with those in the tube. It is thus evident that the aerial micro-organisms do not float about in aggregates, or masses, but as isolated individuals.

Experiments made with the flask method on the dome of St. Paul's tell the same story as those previously made with Hesse's method, and to which I have already referred. These experiments also illustrate the degree of accuracy which is attainable with the flask method.

St. Paul's Cathedral, November 19, 1886.

		Organisms found in 10 liters of air, in each case by flask method.
Golden Gallery..	I	10
	II	11
	III	11
Stone Gallery..	I	25
	II	40
Churchyard		47

NATURE OF THE AERIAL MICRO-ORGANISMS.

The organisms present in the atmosphere are of many different kinds—moulds, bacilli, micrococci, and various forms of yeast or saccharomyces. Of these several kinds of organisms, the moulds have received most attention at the hands of botanists, and, indeed, even the general public is only too familiar with the commoner forms, such as the *Penicillium glaucum*, which is so much at home in pots of preserved fruit, and which is a highly unwelcome guest in the larder. Indeed, some of these moulds appear to be the most widely distributed of all organisms, and are the most difficult to banish from the air. Thus as a general rule, in those places where fewest organisms are found, *e.g.*, at high altitudes and in the open country, the relative proportion of moulds is much higher than in the air of towns and inclosed spaces. It is not difficult to account for this wide distribution of moulds in the atmosphere, when we call to mind their behavior in Hesse's tubes; there, you will remember, the mould colonies were generally found penetrating further into the tubes than any of the bacterial colonies, clearly showing that their buoyancy in air is greater than that of the other organisms, and on this account also they are floated by aerial currents to altitudes and distances which are not reached by the other forms of organisms.

The different kinds of bacilli and micrococci occurring in the air are less generally known, and it is only now that their identification and characterization are beginning to attract much attention. A few forms giving rise to very striking appearances when growing on natural nutritive media, generally articles of food, have been long known, and have at times excited much curiosity. Perhaps the most notable of these forms is the so-called *M. prodigiosus*—really a bacillus, and not a micrococcus—which gives rise to a superb blood-red color, which you see here. This organism flourishes in milk, to which it imparts the same intense color, which was formerly supposed to be due to disease in the cow. It also thrives well on bread, and has occasionally been known to make its appearance on the sacred wafer, where it has not unnaturally given rise to superstitious fear and consternation.

There are several other bacilli or micrococci frequently present in the air, which also produce striking pigments when cultivated on suitable materials. Examples of these I have here:

M. candicans (very common).
Sarcina lutea.
" *aurantiaca.*
M. rosaceus.
M. carnicolor.
B. aureus.
B. fluorescus.
B. aurescens siccus.
B. chlorinus (very common).

Another pigment forming micro-organism which is frequently present in the air is *Saccharomyces rosaceus.* Of the other bacilli, the hay bacillus, or *B. subtilis*, may be mentioned as of very frequent occurrence in the air.

As regards the functions of these various micro-organisms found in the atmosphere, very little indeed is at present known. That the various processes of spontaneous fermentation, decay, and putrefaction, which take place in suitable substances when these are exposed to the air, are due to micro-organisms gaining access from the air, is well established, but only in very few cases has it been shown that particular changes of this kind have been traced to the action of particular and well characterized organisms. Indeed, recent researches have shown that many of the most familiar changes of this kind, such as the conversion of urea into carbonate of ammonia, of ammonia into nitric and nitrous acids, of sugar into lactic and other acids, are capable of taking place through the agency of totally different forms.

Of pathogenic forms, it may be stated that practically none has been demonstrated in the air, but this need not excite surprise, when it is remembered that in all cases in which pathogenic organisms may be expected to pass into the air, as in the drying up of diseased products of various kinds, these pathogenic forms will be accompanied by an enormous preponderance of non-pathogenic or "saprophytic" forms, so that the actual discovery of the comparatively few pathogenic among the overwhelming number of saprophytic organisms becomes an almost hopeless matter. Among the aerial organisms, however, a few have been discovered which are pathogenic to some of the lower animals; thus, quite recently an aerial organism, of comparatively frequent occurrence, has been shown to be identical with a bacillus which was previously supposed by Emmerich to be the inducing cause of Asiatic cholera, and which was discovered by him in the tissues of cholera patients, during the Naples epidemic of two years ago.

Indeed, many of the organisms which have been found in air may be pathogenic to man, although they are not connected with any of the commoner zymotic diseases. In this case, however, it is impossible to make actual experiments in this direction. But it is with the object of excluding such possibly pathogenic forms in the air, that the stringent precautions in the antiseptic treatment of wounds are taken.

But although the organisms connected with the common zymotic diseases have not been discovered in air, yet there can be no doubt that, in the immediate vicinity of the foci of disease, such organisms are present, and that their distribution and conveyance in the air will take place in just the same manner as in the case of those organisms the distribution and conveyance of which, through the atmosphere we have been considering this evening. The investigations on the distribution of micro-organisms, by showing us what circumstances are favorable and which unfavorable to their dissemination, teach us how we may avoid distributive influences coming into play in the case of the organisms of infectious diseases. The scanty microbial population of country, of mountain, and more especially of sea air, which these investigations reveal, points to the security from zymotic disease which these surroundings are well known to confer. On the other hand, we learn that in the air of towns, and still more conspicuously in the air of crowded apartments, we are invested with an atmosphere laden with living organisms, among which, therefore, the chance of inimical forms being present is greatly enhanced. We have seen, however, that in rooms and even in hospital wards the number of organisms is very small provided the air is undisturbed, and this points to the importance of preventing any aerial commotion during the exposure of wounds in surgical operations, and in places generally where pathogenic organisms may be expected. We learn, moreover, the great importance of removing all dust and refuse matter generally in a moist condition, and with the least possible delay, for the micro-organisms present in a moist substance can only be transferred to air in two ways, viz., first, through its desiccation and conversion into dust, and, secondly, through the formation of spray, especially through the generation of gas in the liquid medium—*e. g.*, in the putrefaction of sewage.

In conclusion, I should like to express my opinion that it is the chemical side of bacteriology which at the present moment imperatively demands attention, and which should no longer be suffered to remain in neglect.

In the most prominently attractive department of bacteriology—the pathological—a vast amount of material has already been collected, and, owing to the high degree of perfection to which the methods of studying micro-organisms have been brought by the investigators in this department, much of the difficulty which previously stood in the way of the investigation of the chemical phenomena of bacterial life is now removed.

THE CONSTANT OF ABERRATION.

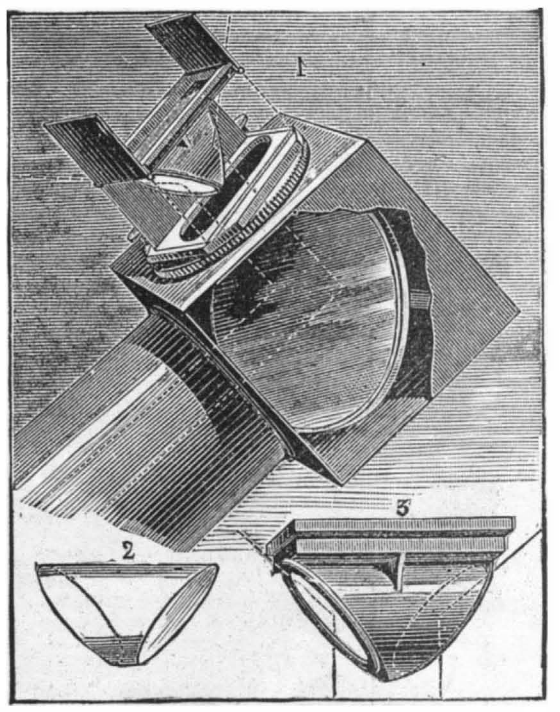
THE question that we are to consider is that of the aberration of light. The so-called fixed stars, as well known, really have motions, although these seem to be very slight on account of the great distance of each of the stars from us. There is nothing stationary in this world, either among organized or unorganized objects, from the atom to the star.

In addition to real motions, there are apparent ones. Thus, among others, each star seems to have an annual motion, and this results from the motion of the earth around the sun. Yet this motion is not the only one, but is involved with another that is due to the fact that the light from a star takes some time to reach us. Just as the sound of a bell or a gun does not reach us until after a certain interval of time that depends upon the distance of the bell or gun from us, so light does not reach us until the end of a period depending upon the distance that we chance to be from the luminous body. Light, as well known, travels at the rate of 192,000 miles per second. Now, the earth moves at the rate of 19 miles per second in the curve that it describes around the sun. The velocity of light, then, is ten thousand times greater than that of the earth; but, however great it be, absolutely or relatively, it is comparable with that of the earth.

What results from this double motion? A comparison will make this understood. Suppose that the rain is falling vertically, in calm weather; then, if you remain immovable, umbrella in hand, the rain will fall all around you, and the umbrella will protect you. But if you walk along, holding the umbrella erect, it will no longer be the same, for you will get wet in front; first, your shoes will get wet, then the bottom of your trousers, and finally your upper garments, in measure as you walk faster and faster. Imagine, in fact, a drop falling from the edge of the umbrella, from a height, say, of five feet. It will take a certain length of time for it to reach the earth, and during this period you will meet it as you proceed. The quicker you move forward, the sooner you will meet it, that is to say, higher and higher up on your person will it fall and you can avoid it only by slanting your umbrella forward at an angle depending upon the rapidity of your gait.

Let us now return to our observer, who has his eye at the telescope, and who is receiving, not water, but light. It will be necessary for him to incline his instrument in such a way that the light shall traverse the length of it while he himself is advancing, as a result of the motion of the earth. The observer may then think that the telescope is giving him the true direction of the star; but such is not the case. It is just as if, in the preceding comparison, we thought that the rain was coming toward us in the direction of the inclined umbrella. So we do not see the stars in their true place, and herein consists the aberration of light. The angle formed by the two directions—the apparent and the real—is the angle of aberration. The effect of aberration was first ascertained by the illustrious English astronomer Bradley, about the year 1725. It was while trying to account for the periodical variations observed in the zenithal distance of a star of Draco that he was led to this discovery, as well as to that of notation. The cognition of the aberration of light has confirmed that of its velocity, and has permitted of indirectly determining the solar parallax, and consequently of verifying the figures obtained by other methods. It is therefore a discovery of the first rank, and the exact determination of the constant is a matter of great importance.

There are several methods of determining and correcting aberration, but they are unfortunately very complex, and require long and patient observation. What renders such research especially delicate is the multiplicity of the errors that may be committed, and that may vitiate the accuracy of the result—accidental errors in observation, errors in instrumental constants, errors in clocks and personal equation, uncertainties



APPARATUS FOR CORRECTING THE ABERRATION OF LIGHT.

due to too inaccurate a determination of the precession of notation, and an insufficient knowledge of the proper motion of the stars and their parallax.

Any method that would permit of avoiding these numerous dangers, and of surmounting every difficulty, should be regarded as a remarkable discovery, and, better still, as a genuine benefit. We owe such a method to Mr. Loewy, of the Institute.

Instead of comparing the absolute positions of the stars, this gentleman takes differential observations as a basis. A double mirror formed in the same block of glass is placed in front of the telescope objective, and sends into the field of the instrument the images of two stars belonging to different celestial regions; and then the slight angular distance of these two neighboring images is measured. These two stars are observed at various determinate epochs, and then the results obtained are compared in couples. The difference in the measurements furnishes a multiple value of the aberration independent of errors due to the instrument. The measurement of the arc comprised between the two stars is independent of the precession and notation. If the angle of the two mirrors is 45°, we shall obtain, for two zodiacal stars, a variation in the distance equal to twice the constant at the end of three months, and to thrice the constant at the end of six months.

As the angle of the mirror is liable to be modified through variations in temperature, Mr. Loewy gives a process that permits of determining the expansion of the mirror and of taking it into consideration. To this effect, an observation is made of one of the pairs of stars in which the effect of aberration upon the distance remains *nil* for the entire year. The difference between the measurements effected at different epochs will make the variation in the angle known, if any such exists.

The following is the principle of the method, which is absolutely accurate: We determine the sidereal instant in which the direction of the earth's motion happens to be in the plane of the horizon. Starting from the longitude corresponding to such direction, we determine the co-ordinates of two pairs of stars, so that the four stars shall be daily at the same height above the horizon, and that the effect of aberration shall be notable upon the two distances, and of contrary sign. Then, at the same physical instant, we compare the two arcs included between the two pairs of stars.

These observations are continued for three months, and we thus obtain a series of determinations of the constant with the greatest accuracy.

The very phenomenon of aberration is thus observed, and the constant estimated solely by the aid of observations made in the evening, without the intervention of any foreign elements. No astronomical operation can reach the degree of precision obtained through a comparison of two contiguous stars in the field of an equatorial. Such is the method by means of which we obtain each particular value of the aberration, based upon a hundred points.

In the accompanying figure, 1 represents the apparatus mounted upon a telescope; 2 is the double mirror; and 3 shows the mounting of the mirror.—*La Nature.*

THE ALBINO BEAR IN THE ZOOLOGICAL GARDEN AT DRESDEN.

THE occurrence of albinism among animals, particularly among birds, has often been noticed. In the European fauna alone there are about sixty different species of birds in which albinos are known; and they are often found among mammals, such as the deer, foxes, wolves, etc., but more particularly among rodents, and even among snakes and fishes.

The Zoological Garden at Dresden at present possesses a number of albinos, among which are a doe, several rats and mice, three blackbirds, two starlings, and a magpie, but its greatest wonder is an albino "collar bear." Albino bears have never before been found, and therefore this one stands alone in natural history. There was great surprise when cubs of different colors were found in the nest of the mother bear, there being one white one and one black one. But they thrived, and soon formed the center of attraction; the droll, quick movements of the little captives entertained visitors by the hour.

New-born cubs are generally small in comparison to the size of their parents, being scarcely larger than rats, and they develop very slowly. They do not begin to see until after five weeks, and for the first three months take no other nourishment than their mother's milk. The irises of the little albino's eyes are red, his claws are yellowish white, and his snout and feet are flesh colored. The name "collar bear" does not seem to belong to him, for he is all white, and the uninitiated often mistake him for a polar bear. His white fur is as beautiful and thick as the hair of the old black ones.

When the two cubs were first put into the large cage which they still occupy, the albino had the misfortune to fall from the perch into the basin. He was very much frightened by his involuntary bath and trembled in every limb when carefully fished out by the mother bear. After every corner of the new dwelling had been thoroughly inspected the first lessons began. The mother bear took great pains to teach her children, coaxing them and giving them choice bits; but the cubs soon outwitted their teacher, and would even snatch the best pieces from under her nose. To be sure they often received a strong reproof for such behavior, but they had not learned that obedience is the first duty of children, and vied with each other in the attempt to gain an advantage over their mother. These cubs have now grown up, and the old bear has other duties to attend to. On the 18th of January, almost the birthday of the three-year-olds, she again gave birth to a white and a black cub.—*Illustrirte Zeitung.*

THE ALBINO BEAR IN THE ZOOLOGICAL GARDEN AT DRESDEN.

SPRING MIGRATION IN CENTRAL NEW YORK FOR 1887.

E. M. HASBROUCK.

THE collecting season in Central New York for the past spring, although lacking in some respects, was, upon the whole, satisfactory to those interested in the subject of migration. The season was unusually backward, and as a consequence when the birds did come, they came with a rush and nearly all in a body, thus making the time for observation extremely short; and while most of the species which pass through the central portion of the State were observed, still there are a number of commoner ones that, in the hurry and confusion, were entirely overlooked, conspicuous among which are the cuckoos and the belted kingfisher.

The following list of eighty-five species covers the time from Feb. 26 to May 21 inclusive, and is made out according to the schedules furnished by the agricultural department at Washington.

On Feb. 26 the first advance may be said to have occurred, and was represented by the first Wilson's snipe, of which one specimen was observed; seen again on the 27th; and afterward the species was lost track of. March 5 brought two species—the song sparrow and red shouldered hawk. Of the former, two specimens were seen, not noticed again until the 12th, and becoming common April 1. It is a common summer resident and breeds. Of the latter but one was noticed. Observed again March 21, when they were numerous. Common resident, and breeds.

The first robin arrived March 6, when one bird was seen. March 8 brought the next one; but they did not become common until April 7. Resident, breeds.

March 9 saw a red tailed hawk, but, contrary to the usual routine, the next one was not seen until April 1, when they were quite numerous. They are numerous throughout the county (Onondaga), and breed sparingly. March 12: This was the first day on which any decided move was made, and was characterized by six arrivals, viz.: Bluebirds, eight; cow buntings, four; red winged blackbird, one; sparrowhawk, one; buffle head duck, one; herring gulls, twelve.

These were observed again respectively on March 18, April 1, 2, and 4 (buffle heads lost track of); became common April 1, 9, respectively (sparrowhawk lost track of); gulls observed again March 20, becoming common April 9. With the exception of the last two, all are common and breed. These last are transients. The first purple grackle and first meadow lark arrived on the 13th, one of each. The grackles were observed again on April 1, became common April 9. Is common and breeds. The larks were seen again April 3, were common by the 10th. Resident, breeds

April 1 brought three more arrivals—the phœbe, one; tree sparrow, one; and mourning dove, one. The phœbe was noted again April 4, became common the 10th, resident, breeds. Tree sparrow noted again April 4, common the 9th, resident, breeds (?) Mourning dove observed again April 10, became common the 23d, resident, breeds.

The first pigeon hawk appeared April 2, and afterward lost track of, resident, breeds. The slate colored juncos came April 4 in considerable numbers, twenty-four being seen in one flock, and several others noticed. Observed again on the 7th, became common the 9th, last seen May 5, breed occasionally. On April 6 the marsh harrier put in an appearance in the shape of one specimen; observed again on the 7th, and then lost track of, resident, breeds.

The next large wave occurred April 7, and brought five migrants, viz.: Vesper sparrow, fifteen; golden crowned kinglet, one hundred (estimated); fox sparrow, eight; winter wren, three; chipping sparrow, two. The vesper sparrows were observed again April 8, and became common the 9th. Resident, breeds. The kinglets became common the same day they appeared, and were then lost track of. Transient, do not breed. Fox sparrows seen on the 8th, for the second time, became common on the 20th. Transient, do not breed. Winter wren observed again March 8, then lost track of, but see them occasionally throughout the summer, so that although a nest has never been taken here, it is safe to say that they do breed occasionally. Chipping sparrow seen again on the 8th, became common the 20th, resident, breeds. The army of migrants now took a rest for one day, sending but one new arrival on the 8th, viz., the great blue heron; one bird was observed, seen again on the 9th, and became common the 23d; resident, breeds. On April 9, a warm south wind started them again and brought seven arrivals; these were the white bellied swallows, fifteen; pied billed grebe, one; wood duck, seven; old wife, one; Holbœll's grebe, one; eastern hermit thrush, one; golden winged woodpecker, one. The swallows were observed again on the 10th, became common the 17th, resident breeds. Grebes observed again the 17th, then lost track of, resident, breeds. Wood duck seen for second time April 10, became common April 23, resident, breeds. Old wife seen but once; rare, does not breed. Holbœll's grebe again observed April 10, then lost track of; rare, does not breed. Hermit thrush again seen April 10, became common May 3, resident, breeds. Golden winged woodpecker observed again April 17, became common the 23d, resident, breeds.

On April 6, four species of ducks were reported to me that I had not noticed, and which were then common. These were the merganser, hooded merganser, American golden eye, and black duck; none of which are resident or breeders. The bald eagle also was reported, and several were seen flying over the lake on which I was collecting. He is a permanent resident from about the first of February to the last of October, and breeds.

April 12, 14, 18, and 20, brought each a new arrival respectively, viz.: The wood thrush, red headed woodpecker, yellow bellied woodpecker, and white throated sparrows. The wood thrush was observed again April 20, but did not become common until May 3, owing to a spell of cool weather; resident, breeds. Red headed woodpecker observed again April 17, became

common the 23d, resident, breeds. Yellow bellied woodpecker was again seen on April 20, and became common the 23d, transient, does not breed. White throated sparrow, observed for the second time April 21, became common the 26th, transient, does not breed (?) April 23 brought two new arrivals—purple finch, five, and Wilson's thrush, one; the finches were again seen on the 25th, and became common May 2, resident, breeds. Wilson's thrush was observed for the second time on the 24th, became common May 8, resident, breeds On the same day (April 23), I noticed the killdeer plover, which I had not before observed, to be quite common. This species was either very late, or else had previously escaped my notice.

Two days now elapsed, during which migration was at a standstill, but the 26th brought one Towhee bunting and one kingbird. The Towhees were observed again May 3, and became common May 7; resident, breeds. The kingbird was again seen on the 27th, and became common May 7; resident, breeds.

April 27 brought one spotted sandpiper and one lesser yellow legs. The sandpiper was again seen May 3, and became common on the 7th; resident, breeds. The yellow legs were observed for the second time May 4, and then lost track of; transient migrant, does not breed.

The first catbird arrived April 29, observed again May 5, and became common on the 7th; resident and breeds.

Four species arrived the following day, April 30, among which were the first of the warblers and the first of the vireos; these were black and white warbler, two, and the solitary vireo, one, also the barn and cliff swallows, ten and two respectively. The warblers were observed again May 2, and became common on the 7th; resident, breeds. The vireos were seen again May 2, and then lost track of; do not breed. The barn swallows were observed on May 1 for the second time, and became common on the 5th, while the cliff swallows were observed on May 2 for the second time, and also became common on the 5th; both are common residents, and breed.

On May 2, one bobolink, twelve brown thrushes, one yellow-rumped warbler, and one bank swallow arrived. The bobolinks were again noted on May 5, became common on the 7th, resident, breeds. The thrushes were noted for the second time on the 3d, and became common on the 4th; resident, breeds. The warblers were again seen on May 3, the following day, when they were extremely common; last seen on May 8, are non-breeders; while the bank swallows were also observed on the 3d for the second time, but did not become common until the 7th, breed.

May 2 and 3 were extremely warm, and on May 3 occurred the largest wave of the season, as ten species not hitherto noticed were observed. These were as follows: Baltimore oriole, one; chimney swift, four; red bellied nuthatch, thirty (estimated); black-throated green warbler, one hundred (estimated); yellow warbler, four; yellow-throated vireo, ten; least flycatcher, two; Blackburnian warbler, six; crested flycatcher, one; golden-crowned thrush, one. All of these were observed for the second time on May 4. The orioles and swifts became common on the 7th, and are residents and breed. The nuthatches were common May 4; last seen May 6, do not breed. The black-throated green warblers became common May 4; last seen May 15, breed occasionally. Yellow warblers became common May 8; resident, breeds. Yellow-throated vireo became common May 5; resident (?), breeds occasionally. Least flycatcher became common May 6; resident, breeds. Blackburnian warbler was lost track of after May 4, does not breed.

Crested flycatcher became common May 7, resident, breeds. Golden-crowned thrush common on May 7, resident, breeds. Seven fresh arrivals came on May 4, and marked another onward move in the army of migrants. These were: House wren, one; yellow poll warbler, six; black-throated blue warbler, one; American redstart, two; Nashville warbler, one hundred (estimated); warbling vireo, two; and red-eyed vireo, two.

With the exception of the warbling vireo, which was observed again on May 8, all were noted for the second time on May 5. The house wren was common on May 10, resident, breeds. The yellow poll warblers were common May 5, do not breed. The black-throated blue warblers were lost track of after May 5, but do not breed. Redstarts became common May 7, resident, breed. Nashville warblers became common May 5, last seen May 8, transient, do not breed. Warbling vireo common May 8, resident, breed. Red-eyed vireo common May 13, resident, breed. Again two days elapsed, followed by a wave, for on May 7 six more were added to the list. These were the Maryland yellow-throat, four; chestnut-sided warbler, four; short-billed water thrush, three; scarlet tanagar, three; magnolia warbler, one; night hawk, one. All were observed for the second time on May 8. Yellow-throats became common May 10, resident, breed. Chestnut-sided warblers became common May 8, resident, breed. Water thrushes became common May 13, transients, do not breed. Scarlet tanagers became common May 10, resident, breed. Magnolia warblers became common May 10, transients, do not breed. Night hawks became common May 10, resident, breeds.

Indigo buntings came May 10, when about ten were observed; noticed again on the 11th, and common on the 14th, resident, breeds. May 13 appeared the first wood pewees, when two were seen, observed again May 14, common on the 16th, resident, breeds. On May 13, I also observed a bird that had hitherto escaped me, the rose-breasted grosbeak, to be quite common. It is a common resident and breeds.

Migration now ceased until May 21, when the black poll warbler, as usual, brought up the rear of the army. About thirty specimens were observed, and again on the following day, when they were quite common. It is a transient visitant, and does not breed.

HOW TO CAN ASPARAGUS.

OUR beginning in this industry was in a very humble way. Ten years ago we had a season of extraordinary low prices. My partner, Mr. Townsend, then conceived the idea of cutting his asparagus in the morning and canning it in the afternoon, thus preserving its flavor and freshness. At that time the only canned asparagus obtainable was the vile stuff bought up in the open city market forty-eight hours after it had been taken from the beds, already spoiled, and with the points of the heads so far gone in putrefaction as to be ready to drop at the slightest touch. I mention these points for the edification of the many who suppose that because asparagus retains its outward appearance of perfect condition and freshness longer than any other spring vegetable, it is as good and as nice to eat forty-eight hours after gathering as when cooked ten hours from the beds. A more serious error was never made. Asparagus begins to deteriorate ten hours after cutting, and forty-eight hours after cutting, unless it has been kept in an ice-box, it is hardly eatable by the connoisseur.

Mr. Townsend had put up, a year or two previous, a sixteen horse-power boiler and engine to run his cider, grist, and saw mills. The steam from the boiler furnished the heat for cooking, while a little head-work fitted up the cooking apparatus. We utilized the cider mill for canning, and used the barn floor for bunching the "grass" as brought in from the fields. Our barn was arranged as shown at Fig. 1. The "grass" was

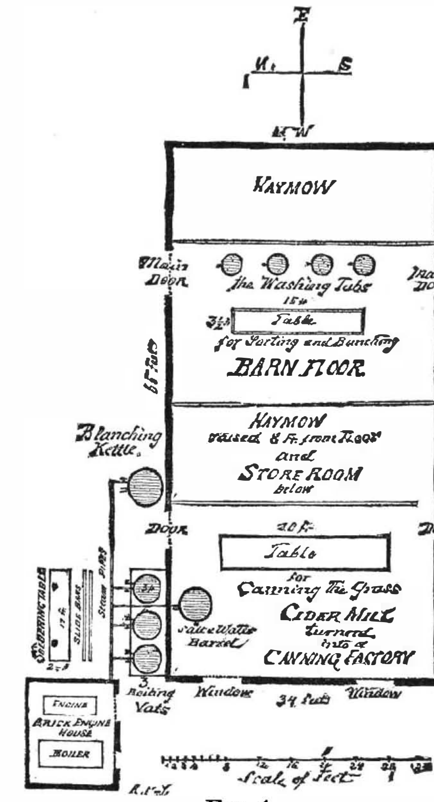


FIG. 1.

cut and carried to the south barn doors in baskets holding about fifty pounds—five-peck baskets with less depth and greater circumference than is usual in baskets of this size. The "grass" was then washed in large tubs (hogsheads sawed in two make excellent ones) by gently pushing it up and down in the water, which was changed as soon as it became foul—see Fig. 2. When thoroughly washed it was placed on a long, narrow table about 15×3½ feet, with a rim three inches high all round to prevent the water carried up on the table with the "grass" from running off on the dresses of the bunchers and sorters—see Fig. 3. The "grass" was taken in hand by two or four well-trained women as soon as it was placed on the table, and sorted into as many different sizes as we intended to can. After sorting it was placed in flat, open trays and carried to the bunchers, who then bunched up the different grades in the regular iron asparagus bunchers. The heads are *all* to be placed up against the wooden head-board of the buncher, and one string is tied around the middle of the bunch—see Fig. 4. The "grass" is then taken out of the buncher and laid on its side until wanted in the canning factory.

The process of cooking was as follows: The "grass" was brought to the factory end of the barn just as it came from the bunchers; it was then cut off the proper length for the cans—6¾ inches if the regulation No. 3 square asparagus cans are used. The "grass" was then placed in a basket or a large copper colander and immersed in the blanching kettle, which may be a double jacket steam kettle costing $125 to the sixty gallons [the jacket kettle is very useful for boiling maple sirup, making cider, jelly, and catsup, cooking feed for stock, and a thousand and one other things about a farm]; or a sixty-gallon barrel may be used

FIG. 2.

with one head knocked out, costing $2, according to the means of the farmer and the extent of the business he proposes to carry on. Pipe fittings for either cost about the same. Both must have valves to allow the water to run in and out, also for controlling the steam supply. The barrel must have a steam coil in the bottom, while the kettle's double bottom acts as a coil. The kettle is preferable, but we worked for years with a barrel. The water in either kettle or barrel must be boiling hot when the "grass" is immersed, and enough live steam must be turned on from the boiler to prevent the cold "grass" from lowering the temperature of the water too much, as too long an immersion in water much below the boiling point, while softening the "grass," makes it slimy and sticky, and gives it an unappetizing appearance when the cans are opened. The "grass" should be kept in the boiling blanching water until it loses the ruddy appearance about the head and becomes a pale green—say from three to five minutes, according to the tenderness and freshness of the stock. The older the "grass," the longer the time. Experience is the best teacher in this operation; no real limit of time can be set by any one.

After being pulled out of the blanching water, the "grass" is allowed to drain for a minute, and is then carefully placed on the filling table. Great care must be exercised in transferring it from the basket to the table, as the heads are very crumbly, and the points will break at the least touch, thus destroying the beauty and symmetry of the spear. Each bunch should then be spread out on the table to prevent further cooking, for if the "grass" is left in the blanching basket in bunches, or in a heap on the table, it will cook to a perfect mush from the heat gathered in the blanching kettle, and be entirely spoiled. As soon as spread out, each filler picks out four or five large spears and puts them, point first, into the cap hole of the can. The best way to fill the can, if the filler be right-handed (if left, reverse everything), is to place it parallel to the edge of the table, with the cap hole nearest the right hand, place the left hand on the face of the can, with the thumb on the side nearest the worker, and the three outside fingers grasping the can, leaving the first or index finger free to arrange the spears of

FIG. 3.

"grass" in regular order as they are passed in by the right hand—see Fig. 5. We find that three or four large spears at the bottom, three in the middle, and two or three on top give the best satisfaction. When the cans are filled they are placed in iron trays, each holding six cans, and costing $1. The filled cans are then carried to the sirup barrel and filled about two thirds full of salt and water, kept boiling hot by a jet of live steam from the boiler. Packers vary in their mixtures of salt and water; some say one pound of salt to four gallons of water, others half a pound to four gallons. As this is one of the most important points in the whole process of canning asparagus, we would advise any one about going into the packing business to experiment, and, starting with one half pound of salt to four gallons of water, get his trade to taste the goods, and from the opinion thus obtained diminish or increase the quantity of salt.

After they have been filled with "grass" and the salt and water (called sirup), the cans are taken to the capper, who wipes out with a sponge any water that may have run into the cap-crease during the filling process. He then places a cap in the crease, and with a small horse-hair brush touches the edges of the cap and cap-crease with a weak solution of muriate of zinc, then applies a round iron of the shape shown at Fig. 6, touches a small bit of solder (to be bought for about thirteen cents per pound) to the round iron, twirls the iron around once or twice, and the cap is fast. Next

FIG. 4.

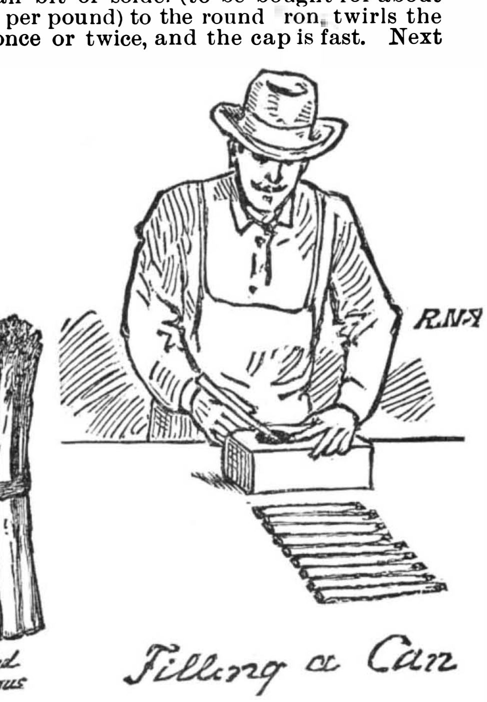


FIG. 5.

he closes up the little vent in the center of the cap, and all is ready for cooking.

Let me add a word of caution here. Some people think that canned goods are rendered harmful by the acid used in the soldering. Never was a greater mistake made, nor did a more ungrounded prejudice spring up, for, when properly sealed, not a particle of

acid can enter the cans. The amount of acid required to seal one hundred cans would not kill a man—would hardly make him ill; but in many of the factories the little center vent-hole is not closed until the first stage of the cooking is over. Here lies the danger; hundreds, yes, in many factories, thousands, of cans are boiled in the same vats with no change of water—result, a concentrated solution of muriate of zinc, together with salts of lead and tin, produced by the contact of the hot iron, the acid, and the solder. The cans, only two thirds full of water, are placed cold in these vats; what air there is in them becoming heated by the hot water, expands, and, passing out through the vent-hole, finally produces a partial vacuum, the foul vat water rushes in to restore nature's order, and we then hear of people being made sick by eating canned goods apparently all right, but in reality all wrong. Dr. Edson, New York City's Health Inspector of Foods, etc., with the wisdom born of getting information from great canning establishments, whose only thought is how many thousand cans they can turn out in a day, advised city people to purchase and use no canned goods with two vent-holes in the cap. Friends, on the contrary, insist, demand, of your grocer that every can he supplies you with shall have this badge of proper preparation and entire freedom from danger of poison, viz., two vent-holes in the cap.

In Fig. 6, *c* is a small iron rod, running through a wooden handle, *b*, a short iron tube, *e*, and a soldering iron, *c*. The lower figure shows a cross-section of this soldering iron. The lower points, *d*, *d*, fit into the cap-crease of the can. When the cap is put on, *c*, which is heated over a fire, is pushed down through *b*, *e*, and *c* to the cap. A bit of solder is put at its point, and then it is twirled around, thus fastening the cap securely.

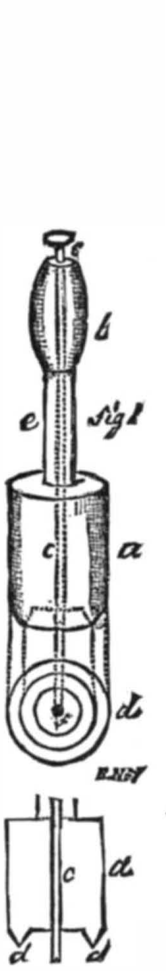


FIG. 6.

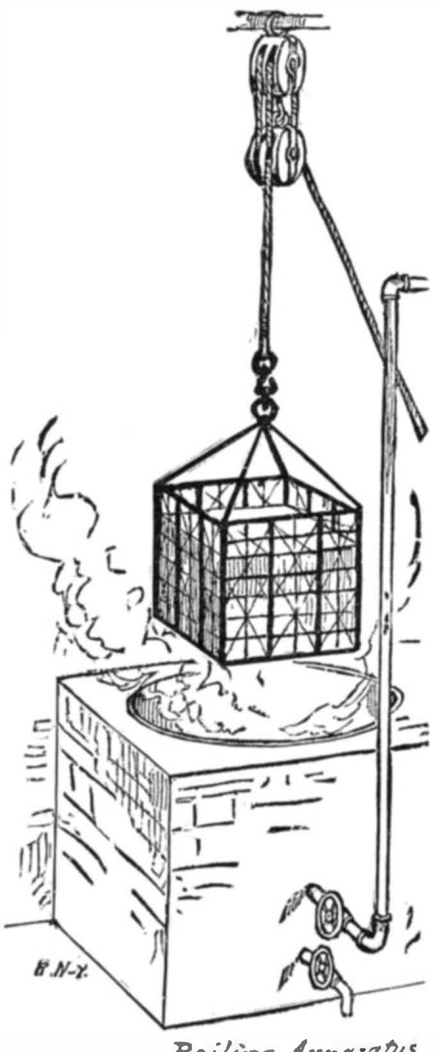


FIG. 7.

To return: Our cans are now ready to cook. They are sealed up air and water tight. Nothing can get into them or out of them until we either burst the can by undue strain or puncture it with an awl. In the bottom of each vat is a coil of steam pipes, and they connect directly with the boiler, a valve at the side of each vat regulating the supply of steam. We turn on the steam to vat No. 1, wait until the water dances and jumps in its efforts to boil out of the vat—no quiet, rolling, monotonous boil as in the kitchen tea kettle or pot, but a mad, frolicsome boil. Then with an iron cage—see Fig. 7—about 3×3×3 feet (the vat is 3·6×3·6×3·6 feet) suspended from a double block and fall, or, what is better, from an equipoise iron pulley, capable of raising 800 pounds with the pull of one finger and holding the weight at any point desired, we lower the cans we have followed through the process, along with, say, 50 or 60 of their fellows, into the vat, there to remain from 20 to 35 minutes, as the packer prefers. Some men of great experience say 20 minutes in preference to 35. The cage and its contents of No. 1 are, at the expiration of 35 minutes, raised from the vat; the cans are spread out on the slide bars—Fig. 1—a pail of cold water is dashed over them, and then the capper (who while No. 1 was cooking has been preparing a batch for No. 2) takes a sharp awl and punches a small hole in the end each can. A small stick is placed under the tray to raise the end where the vent is made. Should the cans blow much steam and water when punched, a piece of bagging, wet in cold water and pulled over them, is useful in preventing too much sputtering. Just as soon as the discharge of steam and gas begins to diminish, the cappers take a No. 3 tinman's flat iron and close up the vent-holes perfectly tight. The cans are then replaced in their cage, relowered into the boiling water, and kept there from 50 to 75 minutes according to the length of time they were cooked before venting—about one hour 40 minutes is the minimum of safety on asparagus. On being removed the second time, the cans are spread out to cool for 30 hours, and then stacked, and when opportunity offers are labeled, packed in cases of two dozen, and shipped to purchasers. Should any leaks be discovered, they should be stopped as soon as the cans are cold. The cans should then be cooked 15 minutes, vented to allow the air to escape, closed up as soon as possible, and then spread out to cool without any further cooking.

A farmer who has a small three or four horse-power boiler, a little knack for handling tools, plenty of go-aheaditiveness, and who is not afraid of hard work, can put up his Saturday, Monday, Tuesday, and Wednesday cuttings, and send his Thursday and Friday "grass" to market, and thus make a good average for his crop.

Square asparagus cans cost about five cents each. No. 3 rounds cost $26 per 1,000; No. 2 rounds, $18 per 1,000. One pound of solder, costing 13 cents, will seal about 52 cans, or at the rate of a quarter of a cent per can. Cases cost 11 to 13 cents each, or from 5½ to 7 cents per dozen cans. Labels cost $3 per 1,000 after the first cost of the plates has been paid. The labor of filling, fuel, etc., costs 12 cents per dozen, and then come freight, brokerage, etc. There is not enough left, after all expenses are paid, to make a man rich in one season, but enough to make him feel happy. We started out with the determination to put nothing but first-class goods on the market; as a result, Delmonico's, the Brunswick, and a half dozen of the best houses in New York City get their supplies from us, to say nothing of dozens of private families scattered from Massachusetts to Dakota. What we have done in this section farmers in other sections can do, and in the end they will find it much more profitable than the old humdrum oats, corn, and potatoes—potatoes, oats, and corn. This year we expect, if nothing goes wrong, to pack 40,000 cans of asparagus, worth $10,000; $500 worth of strawberries, raspberries, etc., and about $3,000 worth of tomatoes. To this extent has our business grown from the puny efforts of ten years ago, when 2,000 cans of asparagus was our limit, and a cider mill, 20×34, our factory. Now we have a two-story building 42×26, with shed 26×52, making a ground plan of 52×68, and a fifty horse-power boiler.

P. H. SCUDDER.

Glen Head, N. Y. —*Rural New-Yorker.*

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