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HIS IMPERIAL MAJESTY WILLIAM I., KING OF PRUSSIA, AND GERMAN EMPEROR.

Born, March 22, 1797; Prince Regent, Oct. 9, 1858; King of Prussia, Jan. 2, 1861; German Emperor, Jan. 18, 1871.

## THE GERMAN EMPEROR'S NINETIETH BIRTHDAY.

GREAT preparations were made in Berlin and throughout Germany to celebrate with due pomp the Emperor's ninetieth birthday, on Tuesday, March 22, 1887. Berlin has been thronged with crowned heads, members of reigning families, mediatized princes, and special envoys. England was represented by the Prince of Wales, who is at home in the palace of his brother-in-law, the Crown Prince of Germany. The Crown Prince Rudolph was the bearer of the good wishes of the Austrian Court, the Czar being represented by a couple of grand dukes; and the brother of King Humbert brought the congratulations of Italy. The King and Queen of Saxony and the King and Queen of Roumania personally assured the venerable Emperor of the esteem inspired by his character; the reigning houses of Denmark and Sweden sent the heirs to the crown; and from far Japan Prince Komatsu brought assurance of the good will of an ancient people destined to play no inconsiderable part in the politics of the world. The Pope addressed a letter to the Emperor William, congratulating him on his ninetieth birthday.

All day (the Berlin correspondent of the *Times* says) a kaleidoscopic panorama of all the royalties, princes, and special envoys was afforded to the gazing and gaping multitudes who surged up and down the Linden, from the Schloss to the Brandenburg Thor, crushing, jamming, shouting, and cheering. Cheer after cheer went up from the sea-like multitude beleaguering the palace, to tempt the Emperor to his window; but his Majesty was too busy receiving the visits of the new distinguished arrivals, and could only yield to the will of his clamorous people when the relieving guard came tramping past.

At night there was a grand torchlight procession, in which between three and four thousand students, representing all the universities and high schools in Germany, took part. It was a brilliant success. The students, bearing flags and banners, took up their position in a long line extending from the palace as far as the opera house, and before the Emperor's residence there was an enthusiastic demonstration of loyalty.

The Emperor and Empress, when the procession approached, occupied seats at the second window on the ground floor of the palace; his Majesty, however, making his appearance some time after the Empress. Herr Munch, president of the students' committee, then rode up to the window at which the Emperor was seated; whereupon the latter rose with the Empress and the Grand Duchess of Baden, the Grand Duke witnessing the spectacle from an adjoining window. Herr Munch then called for "Three cheers for the Emperor, the victorious commander in glorious battles, the beloved father of their country, the author of the union of the German races, the defender of the frontiers of the empire, and the treasurer of the peace of the world!" his remarks being followed by enthusiastic applause. The Emperor repeatedly bowed his acknowledgments. The national anthem was sung, during which the Emperor remained standing at the window. The procession then marched past. During the passage of the procession the Emperor called up several of the students to the window, and expressed to them his thanks and gratification for the ovation paid to him. The Empress also expressed her thanks for the demonstration of loyalty.

A very impressive service was held Tuesday, March 22, morning in the ancient church of St. Nicholas, at which the mayor and about 2,000 representative men of the civil and military governments of Berlin attended in state. At nine o'clock, 250,000 school children having assembled at their respective schools, were conducted to the various churches and synagogues to festival services, at the close of which each child was presented with a book relating to the life of the Emperor.

His Majesty received his distinguished visitors in the Empress' apartments on the first floor of the palace, which were fragrant with piles of all the sweetest flowers of the southern and of the northern spring. In the room adjoining the reception chamber stood the Emperor's birthday table, groaning under the weight of the beautiful offerings made by those nearest and dearest to him, but yet unable to support the many presents littered around. Of all these offerings, perhaps, the most welcome to the Emperor was a full sized portrait of his eldest great-grandson, a bright and beautiful little boy; while his Majesty must also have been highly gratified by a fine large steel engraving of the battle of Rorke's Drift, the gift of Prince and Princess Christian of Schleswig-Holstein. The reception of the Emperor's sovereign and princely visitors did not last long. It was rendered doubly interesting and memorable by the fact that the Emperor profited by the opportunity to announce the formal betrothal of his grandson, Prince Henry, the Crown Prince's sailor son, to the Prince's cousin, Princess Irene of Hesse, granddaughter of Queen Victoria. This was the occasion of a second offering of congratulations by the illustrious throng to the betrothed pair, who left the presence of the Emperor beaming with joy. The Empress, though now somewhat infirm, was there, leaning on the arm of her grandson, Prince William, whose consort led up her little sons to present their congratulations to their imperial great-grandfather. The Emperor actively threaded his way about among his guests; and (says the *Times* correspondent) the gayety of his manners, the erectness of his gait, and the elasticity with which he stooped to kiss a lady's hand at parting must all have tended to make his visitors doubt the fact that he has now lived a score of years beyond the Psalmist's allotted span of threescore years and ten.

The birthday banquet, as usual, was given by the Crown Prince and Princess, and afterward the festive scene was changed to the state apartments of the Old Schloss, where a musical soiree reunited all the chief actors in the day's pageant.

It was a raw night, with a searching rain; but this trifling drawback was not sufficient to damp the ardent curiosity of the tens of thousands who streamed out to look at the illuminations. Berlin was one glowing and picturesque mass of candles, cressets, fantastic gas jets, Bengal lights, and other contrivances of many colored flame.

Brilliant thus outside the Schloss, it was infinitely more so in the White Saloon of that majestic pile, with its blinding coronets and necklets of diamonds scintillating on Empress, queens, and princesses, and the endlessly varied uniforms. The Empress herself, leaning on a staff, was one radiant figure of sparkling light, and Carmen Sylva, the poetess Queen of Roumania, flashed from her neck and forehead a thousand dazzling hues, which even the Queen of Saxony's jewels failed to outshine. The entertainment offered by their Majesties to their guests consisted of a scene from Verdi's "Don Carlos," another from "Don Juan," the chief parts being taken by Herr and Frau Arott de Padilla; a *tableau vivant* recalling the well known money transaction scene between Charles V. and Fugger, the merchant prince of Augsburg; and a Spanish *fandango* scene, executed by the chief members of the opera ballet. In front of the stage which had been extemporized for the performances of these four separate scenes, the court sat in crescent rows, the Emperor in front, flanked by the Queens of Saxony and Roumania, and the others according to their rank and station.—*Illustrated London News.*

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## WILLIAM RIPLEY NICHOLS,

MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

A memorial by Prof. GEORGE F. SWAIN.

IN the death of Professor Nichols the Boston Society of Civil Engineers, as well as the profession at large, has sustained a loss which is difficult to appreciate, and which only those who knew him personally and professionally, and who were familiar with the charm of his private life and the high scientific character of his professional work, can fully realize. To do justice to his character and his work in a notice like this is no easy task, but however much the writer may regret that some one better acquainted with the entirety of Professor Nichols' labors was not selected to write his memorial, he can at least claim to have brought to the task a deep and realizing sense of the gap which has been left in our midst.

William Ripley Nichols was born in Boston on the 30th of April, 1847. After graduating, at the age of 16 years, from the Roxbury Latin School, he spent nearly two years abroad, in company with three companions from the same school, and with his former instructor. During this period, which was largely spent on the Continent, he laid the foundation for that proficiency in modern languages which enabled him to read and write German and French almost as faultlessly as he did his native tongue. In fact, his intention at this time was to devote himself to the study of languages, and on his return from abroad he entered Harvard College with the class of 1869. He had attended that institution, however, but a few months when some trouble with his eyes compelled him to withdraw, and he soon after entered the Massachusetts Institute of Technology, from which he graduated in 1869. His career as a teacher was early begun. Even before graduating he had given instruction in modern languages, and immediately after receiving his degree he was appointed instructor in chemistry, the science to which he had particularly devoted himself during his course. Promotion soon rewarded the earnestness and zeal which he displayed in his work. In 1870 he was made assistant professor, and in 1872 professor of general chemistry—a chair which he occupied uninterruptedly until his death. But four professors in that institution remain whose connection with the school dates back farther than that of Professor Nichols.

His literary work was begun very early, even before his graduation from the Institute. A paper "On the Chromites of Magnesium," published in 1868, and two in 1869, on the oxalates of sodium, potassium, and ammonium, were extensively copied and quoted in foreign periodicals. He very soon, however, began to devote particular attention to questions of water supply, and to other matters pertaining to the public health; and in 1870 he commenced a series of investigations for the State Board of Health of Massachusetts, which brought him prominently before the public, and soon procured for him a high and enduring reputation as an eminent authority on such subjects.

Most of the reports of the board, from this time on, contain articles from his pen, often embodying the results of laborious research, and treating of such subjects as the action of Cochituate water on lead pipes, the composition of the ground atmosphere, the filtration of water, the condition of certain rivers and ponds in Massachusetts, the disposal of sewage, the pollution of streams, etc.

His report on the filtration of potable water, which originally appeared in the report of the State Board of Health for 1878, was in such extensive demand that it was published separately by Van Nostrand, and met with a wide circulation. In 1879 he contributed the chapter on "Drinking Water and Public Water Supplies" to Buck's "Hygiene and Public Health," and in 1883 he again appeared with a volume on "Water Supply, considered mainly from a Chemical and Sanitary Standpoint," a work which at once took its place as a standard authority on the subject He soon became recognized as one of the leading authorities in this country on the subject of water analysis, to which he devoted special attention, and his advice and opinion have been sought by many of the large cities and towns in New England, as well as by many in other parts of the country. His activity in this line of investigation was uninterrupted, and at the time of his death his more extended published reports on subjects of this kind numbered about thirty. Notwithstanding this, he found time for literary work in various other directions, as well as for much of a purely chemical character. In 1872 he published an "Elementary Manual of Chemistry," abridged from Eliot and Storer's "Manual," which was the first book that ever met with marked success for teaching chemistry in the laboratory; and in 1873 he followed with a revision of the qualitative analysis of the same authors, which was also favorably received.

Still, his labors in his chosen field were so extended and so minute as to leave him no time for many of the other important branches of chemistry; nor did he have any desire to dissipate his energies by attempting to cover too much ground. He paid little or no attention to modern organic chemistry or to manufacturing chemistry, but built his reputation upon his work as a sanitary chemist and a teacher of general chemistry.

Probably the most striking characteristic of Professor Nichols' work lay in his minute and painstaking accuracy. He never jumped at conclusions; he was never satisfied until he was sure that he was right. Chemists who well knew him stated that the painstaking care which he bestowed on his work exceeded anything which they had ever known. He was not a manipulator, and did little of his chemical work with his own hands, but was emphatically a head worker, a man of much executive ability, than whom no one knew better how to plan and carry on a complex investigation.

The amount of time and money he spent in simply verifying his results to satisfy himself of their exactness was very large. He kept a private assistant constantly employed, more than half of whose time was generally spent in this way. He would take up a new method of water analysis, and keep his assistant on it for weeks, verifying its accuracy on solutions previously prepared. He even sent one of his assistants to England for the express purpose of studying Frankland's method under the direction of that eminent chemist himself. Only a small fraction of his analytical results has been published, but of their absolute accuracy there can never be any question; and his series of investigations for the State Board of Health will always remain classic and models of their kind. His enthusiasm in his work was unbounded, and he lost no opportunity of adding an item of information to his store.

He was a member of many scientific societies, whose meetings he always attended when possible, and he made it a point during nearly every long vacation to be present at the gathering of some learned body. Even during the last year of his life, when his strength was slowly but surely ebbing away, his enthusiasm was not checked in the slightest degree. He would cross the ocean, attend the meeting of some learned body, and return to his work with renewed zeal and strength. Even this very year it had been his hope to attend the meeting of the British Association—but his end was nearer than he thought.

Professor Nichols was one of the few sanitary chemists who thoroughly appreciated the close relation between his specialty and the various branches of engineering, and his knowledge of engineering works, details, and methods was by no means insignificant. Besides associating and affiliating with engineers, he was actively interested in this society, and in the various water works associations, and he had repeatedly been solicited to join the American Society of Civil Engineers.

His industry was remarkable. He was always engaged in some research, and was never satisfied unless he was accomplishing something. Confined as he was a great portion of the day to his work at the school, he was in the habit of doing most of his literary work at night, working till very late and rising early to resume the welcome task. He never neglected an opportunity to visit a locality where anything of interest in his favorite line of study was to be found, and he personally inspected most of the principal water works and sewerage systems of Europe. He had a large acquaintance and correspondence with sanitary chemists and engineers throughout England, Germany, and France, and his reputation there was as high as in this country. He was a frequent contributor to the *Sanitary Engineer*, the *Journal of the Franklin Institute*, and other technical periodicals, and he made it a rule to present at least one paper every year before this society. But notwithstanding these multifarious employments, he never seemed in a hurry, and found time for other work to a degree which was astonishing. He was too busy to mix much in society, but was very much interested in church affairs, holding for many years the position of clerk of the Highland Congregational Society and Assistant Superintendent of the Sunday school. He was never absent from the meetings of the trustees, even when so weak that he had to be brought in a carriage, and less than eight months before his death he accepted the responsible post of superintendent of the Sunday school.

His knowledge of books was enormous. He procured every book, pamphlet, or report which appeared in this country or in Europe on sanitary science from a chemical standpoint, and at the time of his death he had accumulated what was probably the finest library in this country on those subjects. He was very methodical, and kept a card catalogue of every work in his possession, numbering about one thousand volumes, besides a very large number of pamphlets. He did a great deal of bibliographical work, setting an example which we would like to see more generally followed. His works abound in copious references, and at the end of many of his important reports and papers he added a valuable bibliography of the subject. He also prepared the list of Count Rumford's works published by the American Academy in the complete works of Rumford, and in 1881, while confined to his house by the sickness the result of which five years later carried him away, his active mind would not endure enforced idleness, and he busied himself in compiling a complete catalogue of the works or articles published by graduates or teachers of the Institute of Technology.

As a teacher, Professor Nichols will long be remembered by all who came in contact with him as pupils. He always stood ready and willing to aid those who were anxious to learn, and in him the students had before them always a high and inspiring example of the most careful and painstaking accuracy. If to some he appeared at times unnecessarily severe, it was but a consequence and a manifestation of the high standard he set for himself, and to which it appeared to him that others ought also to conform.

Five years ago, in June, 1881, Professor Nichols contracted a violent cold; but the seeds of disease had been sown before, and this was all that was needed to bring forth their fruit. He had overtaxed his strength in the years gone by—lived beyond his income—drawn on his physical capital. During the winter of 1881 he was confined to his house, reluctantly enough, for until then he had never missed a recitation, either as student or professor. In the spring of 1882 he returned, weak and enfeebled, to take charge of his classes.

His cold had developed into pneumonia, which had been followed by pleurisy, and this had finally left him with empyema, from which he never recovered. Yet his spirit was not quenched, and from the time when he was again able to resume his classes he pursued his work with a pluck and determination that was perfectly marvelous, and that can only be termed heroic. Though perfectly well aware of his precarious physical condition, and under circumstances in which most

men would have kept their beds, he attended regularly to his classes, and did not, I believe, miss a single exercise until his death. He was always cheerful, sometimes even gay, and his wonted wit and humor sparkled as ever. No one would have suspected from his conversation that he was in anything but the best of health.

In the summer of 1884 he was in England, and returned refreshed and apparently better. But he soon grew worse, and in the spring of 1885 he was obliged to leave his home in Roxbury and to take rooms at the Hotel Brunswick, not being strong enough to travel back and forth every day. In the summer a serious operation was performed, apparently with beneficial results. But during the winter of 1885-86 he was so weak that he was obliged every day to travel between the railroad station and his house or the school in a carriage. Still he did not miss a recitation, and during all this time he was laboring as of old, making investigations in his favorite studies and contributing articles to various magazines. No word of complaint escaped him, though he knew his end was not far off, and he worked as before to the limit of his strength.

During 1884-85 he had been busily engaged, conjointly with Professor W. T. Sedgwick, on an investigation for the State Board of Health, concerning the relative poisonous qualities of common illuminating gas and of water gas, and at the time of his death he was engaged in the preparation of an index to th literature of carbonic oxide, and also, with Professor L. M. Norton, in preparing a dictionary of chemical synonyms, thus indulging both his scientific and his bibliographical tastes.

Even as late as May 19 of the present year, he appeared before this society—his last public appearance—with a paper on the use of galvanized iron and some other service pipes for conveying water. That he fully appreciated his physical condition during all this time is shown by the following words, which occur at the close of the preface to his compilation of the publications of teachers and students of the Institute: "This work will be kept in such shape that in case of accident to the present compiler some one else can readily take it up and carry it on." The accident came.

In June, 1886, he went abroad to consult eminent medical authority. Another operation was advised and submitted to, but his strength was too far gone. He could not rally, and on July 14, at Hamburg, Germany, he quietly breathed his last.

He was a member of the following scientific and engineering societies, the mere enumeration of which will show how wide was his reputation: The American Academy of Arts and Sciences; the American Association for the Advancement of Science (of which he was, in 1884-85, Vice-President of the Chemical Section); the New York Academy of Sciences; the American Public Health Association; the Boston Society of Natural History; the New England Water Works Association; the Society of Arts; the Deutsche Chemische Gesellschaft; the London Society of Chemical Industry; and the Boston Society of Civil Engineers.

After his return from England in 1884, he received from the managers of the International Health Exhibition a certificate of thanks and a bronze medal "for services rendered."

On Professor Nichols' private life it is unnecessary to dwell here, but those who knew him will not soon forget his cheerful, generous, and thoughtful dispositon and his sparkling wit and humor. He was a most enthusiastic friend of the Institute of Technology, to the success of which school he had so largely contributed by the devotion of a life time. There his memory will long remain green. Those who were associated with him will need no reminder to recall his presence, while his magnificent library, bequeathed to the school, will be his monument for future teachers and scholars, inspiring them to emulate his work, his devotion, and his high example.—*Jour. Assn. Eng. Socs.*

## WILLIAM DENNY.

WILLIAM DENNY.

BY the death of Mr. William Denny, of Dumbarton, which occurred on the 18th of March last, at Buenos Ayres, South America, the ship building world has lost one of its most distinguished leaders, the well known firm of William Denny & Brothers one of the most intrepid and skillful managing partners, and a wide circle of relatives and friends one who was endeared to them by all the best qualities of heart and mind. The engraving which we publish is taken from a photograph of the deceased gentleman, who left Dumbarton for the River Plate about eight months ago, partly to attend to the affairs of La Platense Flotilla Company, of which concern he was chairman, but mainly in the hope that his health, which was far from robust, might be benefited.

About two years ago, while on the Continent, he had a serious attack of typhoid fever, and never having sufficiently recovered from the after effects of this illness, it was thought that the change would be beneficial. Those acquainted with the deceased gentleman will not be surprised to learn that he applied himself too assiduously to the business on hand, neglecting th main object of his journey, and shattering his already enfeebled health. Under the abnormal strain his brain gave way, with the result that he terminated, by his own hand, a most useful life and a career already highly distinguished.

The deceased was the eldest son of Mr. Peter Denny, of Helmslea, was born at Dumbarton in 1847, and was thus, at his death, in the fortieth year of his age. He received his elementary education in Dumbarton, and afterward proceeded to Edinburgh High School, where he remained till he was seventeen years of age. His education there was of a purely classical nature. The scientific knowledge and theoretical acumen he evinced in after life were, for the most part, self-acquired while he was engaged in the various departments in Leven shipyard. In 1870, when only twenty-three years of age, he was made a partner of the firm, and shortly afterward he joined the engineering business of Messrs. Denny & Company, a separate firm, but one in which the leading members of the Denny family have always been represented.

Recognizing the intrepidity, energy, and great administrative ability of his son, Mr. Peter Denny, in the course of a few years, gave way to him in matters connected with the active management of their establishment. Under his administration, the cordial relations always subsisting between the firm and its workmen have been maintained and strengthened, and the *prestige* of the yard, as one of the most scientific in its methods, has been greatly enhanced. It was not a feature with Mr. Denny to take for granted what was ordinarily accepted as true or "near enough the truth for all practical purposes," but his steadfast aim was to attain to the truest and best in all things. This being so, everything throughout the establishment was ordered accordingly, and many departments and skilled workers not ordinarily considered indispensable, even by firms of similar standing, were instituted and kept in operation in pursuance of this high standard. To chronicle, with anything like ordinary fullness, the various matters with which he identified himself, would unduly extend this notice, but a sentence or two with regard to the chief of them may fittingly be given.

In 1875, Mr. Denny was awarded a gold medal by the Institution of Engineers and Ship Builders in Scotland, for a valuable paper upon "The Difficulties of Speed Calculation." About the same time he instituted the system, now well known and largely followed, of trying merchant steamers for speed, progressively on the measured mile, the practice having previously been applied in several instances to ships of the navy.

The subjects of speed and resistance of ships, and the analysis of the various elements constituting total resistance, were favorite studies of Mr. Denny's ever after. He read several papers before the Institution of Naval Architects on the subject, and never failed to add to the interest and value of discussions following similar papers read by other members. Appreciating the value of the experimental work with ships' models conducted by the late Dr. William Froude, F.R.S., and still carried on by his son, Mr. Denny established an experimental tank in connection with the works, similar to Dr. Froude's at Torquay.

This unique department in a private shipyard has now been in operation for about four years, and a special staff of experimentalists, forming a branch of the general scientific body in Leven shipyard drawing office, is employed conducting experiments and accumulating data, which, besides proving highly serviceable in present practice, must ultimately yield fruit of a very special kind to the firm. Another important matter with which the name of the deceased gentleman is closely identified is that of the introduction and development of ship building in mild steel.

Early in 1879, the order for a large steamer for the transatlantic trade was given to Messrs. Denny by Messrs. J. & A. Allan, of the Allan line. Mainly owing to the strong representations of Mr. William Denny, it was arranged that the new vessel should be built of mild steel, be riveted with the same material, and have her boilers also of steel. This was the Buenos Ayrean, launched in 1879, and the first steamer in the Atlantic service built of mild steel. He introduced, at considerable cost, valuable testing apparatus, similar to that used by Prof. Kennedy at University College, and engaged experts to conduct tests upon all the material entering the yard, in order to satisfy all concerned in the structure of the ship as to the reliability of the material.

In the following year he read a paper before the Institute of Naval Architects, on "Steel in the Ship Building Yard," in which he advocated extended use and ordinary fair play for the new material. Mainly through his advocacy, the testing of steel by the registry surveyors, and others, was arranged to be conducted at the steel works in place of in the shipyards. In this way, the expense and delay caused by imperfections being discovered after the material had been delivered in the shipyard were obviated, and a serious economical objection to its employment removed. On the economical advantages of steel ship building, Mr. Denny also spoke often, and strongly. Both in the societies with which he was connected and in the conduct of his firm's business, his powerful advocacy did very much to help the progress of steel. All the ships built by Messrs. Denny for several years, with one exception, have been built of the new material.

Almost contemporaneously with the introduction of steel, the modern system of fitting structural double bottoms for water ballast received greatly extended adoption. Neither the Clyde nor any particular Clyde firm can claim to have originated the system of fitting water ballast bottoms forming an integral part of the structure, but Clyde builders, and notably the subject of our notice, were the first to give decided impetus to the movement.

Adopting it about seven years ago, in four sister vessels for the British India Steam Navigation Company, Mr. Denny, on behalf of his firm, subsequently raised the important issue with the Board of Trade as to whether the tonnage of these vessels should be measured to the top of the inner bottom or, as this body maintained, to an imaginary line half way down the cellular space—in fact, to where the line of floor would have been if constructed in the ordinary fashion. It was maintained by Messrs. Denny, and the court upheld their contention, that as the register tonnage was meant to be a measure of the space available for cargo, the top of the ceiling on the inner bottom was the only equitable line of measurement.

The position taken by the Board of Trade seems to have arisen from the fear that owners would endeavor to use the double bottom for cargo carrying purposes. The fallacy of this, however, has been shown by subsequent experience, and the concession then won by Messrs. Denny removed a serious hinderance to the general adoption of the cellular water ballast system, and gained for the ship owner a lasting advantage.

The important subjects of instability and overloading, to which professional and popular attention has been so forcibly directed of late years, were always matters of deep concern to Mr. Denny, who did much, aided by the large staff at his command, to throw fresh light upon and materially simplify these complicated problems. It has been customary for many years to incline every vessel built by his firm, when in the finished condition, to ascertain the position of the center of gravity, and metacenter, in order to have a measure of her initial stability, and a basis for more elaborate calculations of her stability if required. Latterly, at Mr. Denny's desire, a volume has been issued with every vessel built by the firm, containing information for the use of the owners, captains, and officers concerning the vessel's qualities as to stability in supposed conditions of loading, trim, speed, carrying capability, etc., and, in return, information has been collected from the owners and captains relative to stability in actual conditions of loading, also as to steaming power and consumption of coal, which must have a beneficial effect on future designs.

On account of his well known interest and special knowledge in these subjects, Mr. Denny was appointed a member of the Load Line Committee which recently gave the result of their deliberations in a report. This has done much to help to a satisfactory solution of the load line difficulty. Before this commission he gave valuable evidence, and otherwise served with great usefulness.

Early in his career as a partner in the ship building firm, Mr. Denny distinguished himself in connection with the advocacy and practical introduction of the piece work system into most of the departments of the works. He published a pamphlet on the subject, entitled "The Worth of Wages," conspicuous for its grasp and forcible enunciation of the fundamental principles underlying the labor problem. The success of the piece work system in Messrs. Denny's experience led to its extended adoption in the ship yards and engineering works of the Clyde.

Another matter concerned with the remuneration of labor with which, through his instrumentality, the name of his firm is peculiarly identified, is that of the system of rewards to workmen for inventions and improvements in machinery or methods of work. This was instituted in Leven shipyard in 1880, and still remains in operation, the scheme having proved of substantial benefit to both employed and employers, and has been adopted in several other establishments. Many matters connected with the works might be instanced, to show the deep and more than usually sympathetic interest Mr. Denny took in all the employes of his firm.

The arbitrary and sometimes despotic rule to which workers in large establishments are often made to submit found no counterpart in Mr. Denny's administration. For some years past, it has been the custom of the members of the firm to meet in conference, with delegates appointed by the various classes of operatives, to discuss such matters concerning their mutual interests as hours of work, irregular attendance, penalties for misdemeanor, rates of contribution to the various public charities and to the accident fund established in the works, in the case of the latter two objects it being the custom of the firm to contribute a sum equal to the total subscribed by their employes.

Mr. Denny's loss will be keenly felt at the meetings of the Institution of Naval Architects, of which he was a valued member of council, in addition to being a frequent contributor of papers, as well as a ready participator in discussion. His demise will also be regretted by such bodies as the Iron and Steel Institute, the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Royal Society of Edinburgh, and the Institution of Engineers and Ship Builders in Scotland, of the last of which he was president. In the welfare of the people of his native town he took a deep interest, and was ever ready to assist, both monetarily and by personal effort, the various societies having for their object the advancement of the people in education, refinement, and innocent, healthful amusement. By his death, Dumbarton, as a community, has been thrown into a profound state of gloom over the loss of one who, in a sense, was its leading townsman.—*Industries.*

## THE GREAT EGYPTIAN WATER WORKS.

We have already described one of the water works which supplies the Mahmoudieh Canal and the city of Alexandria, through wheels analogous to those of Sagebien, and actuated by steam. The second water works, those of Katatbeh, likewise take water from the river to feed the Katatbeh Canal, which the slight depth of the supply behind the Saidieh dam renders insufficient during the period of low water. It is a description of these works that forms the subject of this article.

The amount to be furnished every twenty-four hours amounted to 330,000,000 gallons, according to the terms of the first grant accorded to Mr. Edward Easton by the Egyptian government. For lifting apparatus, this gentleman adopted ten Archimedes screws. These apparatus, which were of the type improved by Mr. Airy, were set up in a large basin, 150 feet in length by 50 feet wide, separated from the Nile by a wall that served at the same time as a foot bridge. The water entered the basin through three arches of 23 feet span each, that could be closed by means of gates actuated by hydraulic power. Each screw had a diameter of 15 feet and a length of 39 feet. The heart, which was of iron plate, had a diameter of 4 feet, and was provided with spirals of the same material, ·15 inch in thickness. The iron plates of the shells and screw hearts had thicknesses, respectively, of 0·35 and 0·4 inch. At the extremities of the heart of the screw were arranged an entrance and exit cone, provided with gudgeons that revolved in roller bearings designed to diminish friction. A shaft 16 feet in length actuated the screw through the intermedium of bevel wheels and a cog wheel driven by a pinion. This shaft itself was actuated by the shafts of three compound vertical engines, which were connected with it through cylindrical gearings, so that one of the engines might be thrown out of gear without stopping the others. These shafts made 70 revolutions, and gave the screws a velocity of from 5 to 6 revolutions per minute. These screws, which, like the Sagebien wheels, raised a nearly equal bulk of water at every revolution, and have given good results in various water works, especially those of Anvers, were not of sufficient strength to withstand the enormous stresses that they were obliged to when they were full of water. So they all broke on the very first day at about a third of the length of the screw heart. The work of strengthening the hearts was then undertaken. To this effect, they were connected by iron rods to the shells, in order to render them more solid. But this makeshift was insufficient, and it became necessary not only to replace the lifting apparatus, but also to increase the power, the amount of water to be furnished having been increased by the government from 300,000,000 to 600,000,000 gallons per 24 hours.

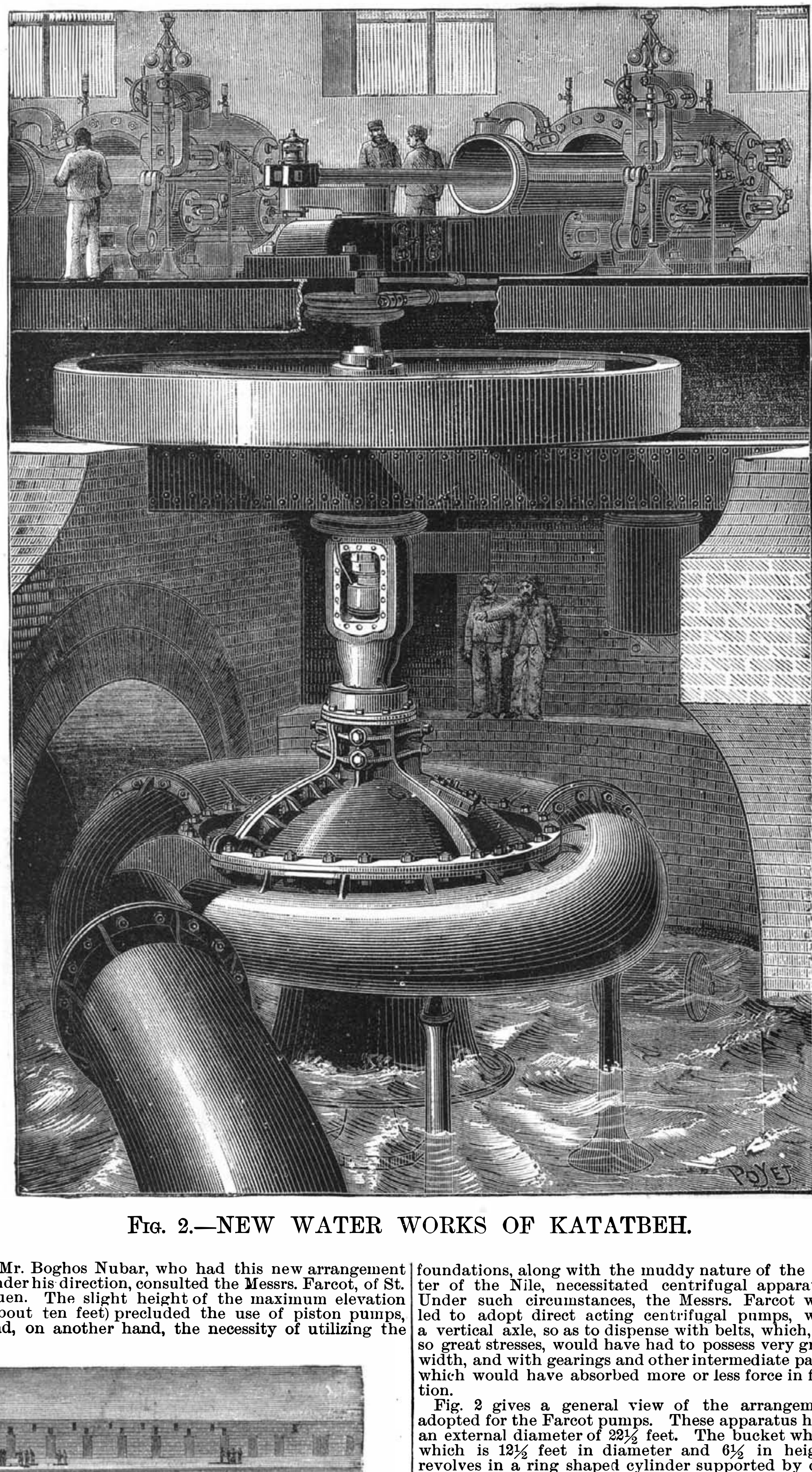


Fig. 2.—NEW WATER WORKS OF KATATBEH.

Mr. Boghos Nubar, who had this new arrangement under his direction, consulted the Messrs. Farcot, of St. Ouen. The slight height of the maximum elevation (about ten feet) precluded the use of piston pumps, and, on another hand, the necessity of utilizing the foundations, along with the muddy nature of the water of the Nile, necessitated centrifugal apparatus. Under such circumstances, the Messrs. Farcot were led to adopt direct acting centrifugal pumps, with a vertical axle, so as to dispense with belts, which, for so great stresses, would have had to possess very great width, and with gearings and other intermediate parts, which would have absorbed more or less force in friction.

Fig. 2 gives a general view of the arrangement adopted for the Farcot pumps. These apparatus have an external diameter of 22½ feet. The bucket wheel, which is 12½ feet in diameter and 6½ in height, revolves in a ring shaped cylinder supported by cast iron columns. This cylinder gradually increases in diameter, and connects with the discharge pipe, which descends and forms a siphon, in order to prevent the loss of priming, and then gradually rises till it reaches the constant level of discharge. At its extremity this pipe is connected with the masonry arch that lets the water into the canal.

In order to permit of the inspection and lubrication of the shaft, the builders have adopted the pivot out of water arrangement used for turbines. The movable part of the shaft connected with the bucket wheel rests upon a column solidly affixed to the masonry, and which rises above the highest level to be expected during the period of operation.

The shaft is hollow, has a hooped head, and has a socket 33 inches long, 23 wide, and 27 deep, into which the pivot enters. This is formed of five lenticular brasses, having alternately convex and concave surfaces, the last of which rests upon a concavo-spherical brass, forming the bottom of the step bearing, and fixed to the head of the stationary shaft. These brasses, which are of phosphor-bronze, have velocities that progressively diminish from the one forming the extremity of the shaft up to the last, which is null, so that the great friction due to the revolution of a shaft 25 feet in length and weighing, with its fly wheel, 50 tons, is distributed over a wide surface. A circulation of oil between the brasses is secured through apertures in the prolongation of the axis of the shaft and oil grooves on the surface of the brasses. The excess of oil flows into a cylinder fixed upon the shaft. In the first arrangement, a jacket concentric with the step bearing gave passage

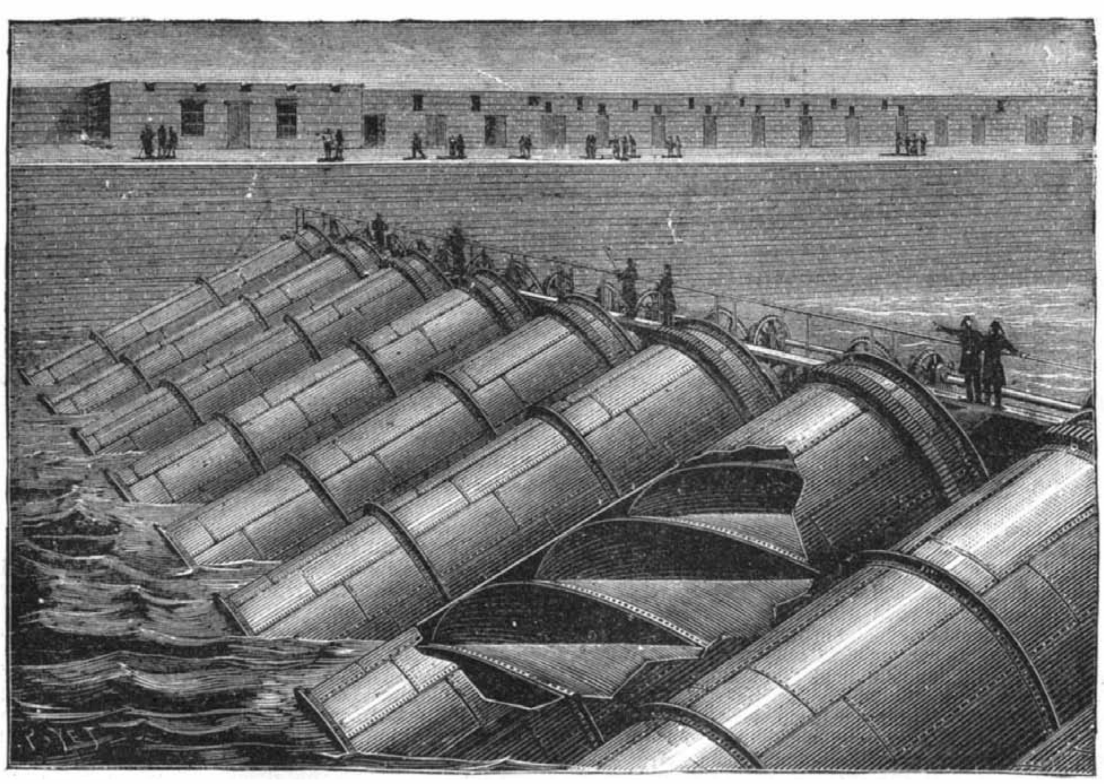


Fig. 1.—THE KATATBEH (EGYPT) WATER WORKS.

to a circulation of water designed to constantly cool the lubricant.

Despite these precautions, it was observed that, as soon as the apparatus was set running, the brasses gave way as if they had been melted. This was due, not to the weight of the shaft, but to the fact that the oil was not cooled sufficiently. The builders were therefore led to study a special system to overcome this grave inconvenience, and the company, having at the same time consulted Mr. Vigreux, had it in its power to adopt two solutions, which it applied simultaneously.

The principle in common consists in drawing from the waste vessel a proper quantity of the heated oil and sending it under pressure to a tubular cooler, and from thence to the brasses to be lubricated. To this effect

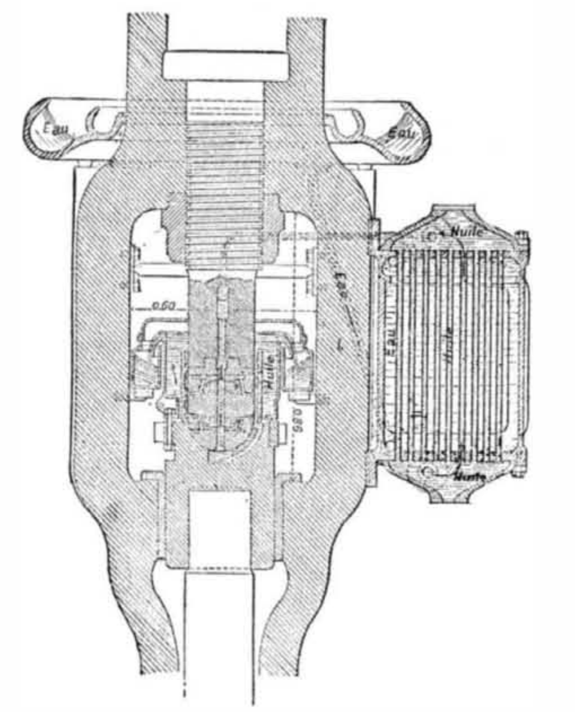


FIG. 3.—FARCOT'S ARRANGEMENT FOR COOLING THE LUBRICATING OIL OF THE PIVOT.

the Messrs. Farcot have suppressed the circulation of cold water in the pivot. The bottom of the receptacle for the waste oil communicates through two tubes with the suction tubes of two rotary pumps of so small size that they can be placed in the eye of the shaft (Fig. 3). The axle of each pump is provided with a pinion that moves upon a toothed wheel fixed upon the step bearing. As the pumps are carried along in the motion of the shaft, they are revolved by the pinion, and their delivery is proportional to the velocity of the engine. They force the oil into a tubular receptacle cooled by a circulation of water coming from the condenser. The cooled oil is always forced under pressure into the axis of the pivot and brasses through a pipe that connects them with the cooler.

Mr. Vigreux's solution of the difficulty (Fig. 4) consists in forcing the oil by means of a special pump outside of the shaft into a tubular cooler fixed upon the floor of the basin, and thence into a reservoir above the apparatus. The oil descends to the pivot through a pipe having the form of an elbow, and communicating with the brasses through a horizontal conduit formed in the crank moved by the engine, and followed by a vertical conduit formed in the axis of the shaft.

These two arrangements, one of which was applied to three of the pumps, and the other to two of them, gave equally good results during the entire season of 1886. The griping ceased entirely, and the apparatus ran uninterruptedly from the time that it was started during the entire period of low water.

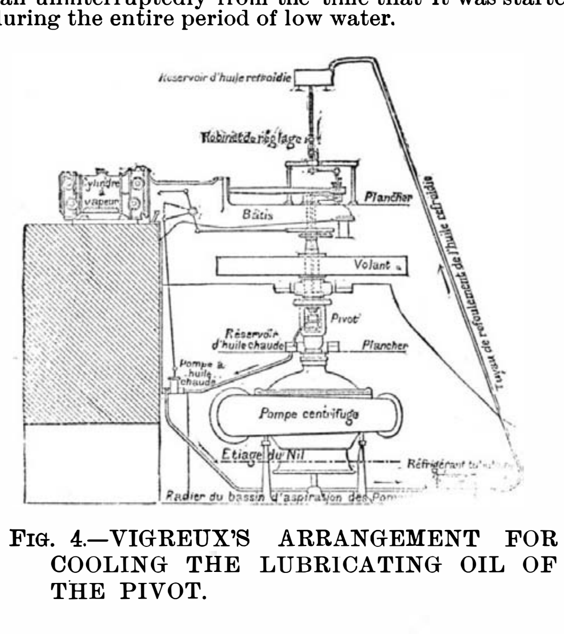



FIG. 4.—VIGREUX'S ARRANGEMENT FOR COOLING THE LUBRICATING OIL OF THE PIVOT.

Each of the pumps is actuated directly by its own motor. These engines are of the Farcot type, with four slide valves, and variable expansion. The cylinders are 3¼ ft. in diameter, and the pistons have a stroke of 6 ft. The fly wheel, which is keyed horizontally to the shaft, weighs 22 tons, and is 22 ft. in diameter. The mean velocity is 33 and the maximum 36 revolutions per minute. Under such circumstances each pump is capable of discharging 132,000,000 gallons per twenty-four hours. The entire capacity of the works, then, including three screws in reserve, that we shall speak of further along, is not far from 7,700,000,000 gallons per day.

Twelve tubular boilers with internal furnaces furnish the steam necessary for the pumps. Three of these, constructed at the Creusot works, have a heating surface of 2,000 square feet; the eight others, which are from the Farcot works, have a heating surface of 800 square feet, inclusive of that of their lateral superheaters.

The Farcots agreed not to exceed 3¾ lb. of coal per horse and per hour in water lifted. The experiments performed during the season of 1886, in which the pumps had to raise water to a height of 10½ ft., which was a little greater than that which had been provided for, and which was due to the remarkably low state of the Nile, gave very satisfactory results, and, in some of them, the consumption of fuel ran down to 3·3 lb.

At present, the Katatbeh works embrace five pumps and five engines, and three of the old screws, which are used as reserve machines. To this effect the screws have been modified and strengthened. A cast iron ring surrounded by a circle of rollers running over a track fixed to the masonry bottom of the basin reduces the load upon the extreme gudgeons, and internal bars connect the heart of the screw with the shell. These screws are driven in the same way as in the first arrangement, but by one engine only, and that an Easton compound one. Through this overhauling they were able to run during the last season without breaking. The want of solidity of the center of the basin floor has obliged the company to preserve the three middle screws, so that the pumps and engines are divided into two groups, one of three and the other of two. The steam cylinders, as shown in Fig. 2, are placed upon the old arches. On issuing from these the force pipes assemble in a canal 90 ft. in width and 6 ft. in depth.

Upon the whole, the two water works of Atfeh and Katatbeh are capable of discharging every twenty-four hours a total volume of 1,320,000 gallons of water. This enormous quantity is furnished with perfect regularity, and the extensive irrigations of the province of Behera are fully secured through mechanical means until a radical change in the Nile shall permit of the continuous feeding of the chief irrigating canals in Lower Egypt.—*La Nature.*

## A NEW AUTOMATIC COMPRESSED AIR CAR.

MR. DE VICQ DE CUMPTICH'S automatic car, represented in Figs. 1, 2, and 3, comprises several new arrangements that permit of the use of compressed air in combination with steam as a propelling agent.

Under the frame of the car and under the seats (Fig. 1) are arranged cylinders charged with air at an initial pressure of 32 atmospheres, and communicating with each other through the pipe by means of which they are charged. This pipe is prolonged in the shape of a worm, which is placed in a small boiler, C, containing water, and heated internally. On making its exit from the boiler, this pipe separates into two branches that terminate in vertical elbows of equal internal diameter. One of these branches is external, while the other enters the regulating reservoir, A, with which it communicates through small lateral orifices. Within the double branch formed by this bifurcation there is a horizontal lever, which is connected, through two vertical rods, with two small pistons. Of the latter,

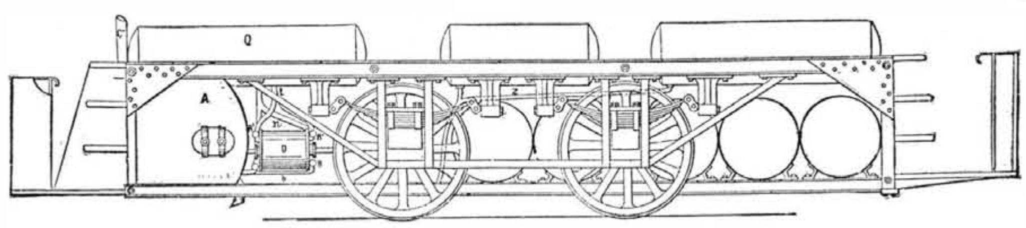


FIG. 1.

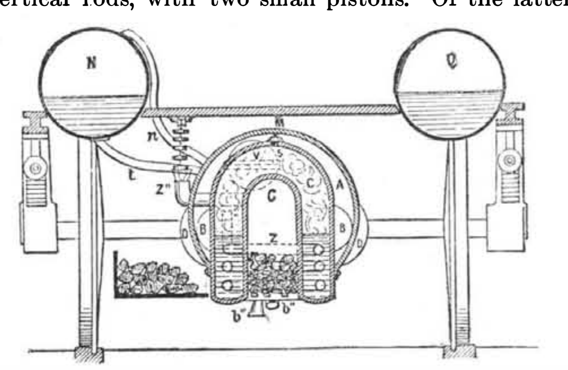


FIG. 2.

the one of the external branch carries a receptacle designed to receive weights, while the other serves to close the lateral orifices. The object of this arrangement is to regulate the internal pressure of the regulator. In fact, if a determinate weight be placed in the receptacle, the horizontal lever will oscillate and the cut off will open the orifices communicating with the regulator, which latter will thus fill with compressed air until the internal pressure, balancing the weight, puts the lever back in its horizontal position and closes the orifices.

The upper part of the boiler is provided with a valve, S, that establishes a communication between it and the regulator, A. This valve rises when the pressure of the steam is greater than that of the air contained in the regulator. The steam then enters the latter, partially condenses, and yields up to the air its heat of vaporization, while the non-condensed portion mixes with the air and acts like the latter in the motive cylinders, B D. These latter are two in number (Fig. 3), the air acting under full pressure in one, and expanding in the other. The distribution is effected by a slide valve, and the eduction pipes continue as far as to the large cylinder, where the air acts by expansion, and is afterward led under the fire box, where it quickens the draught. In order to remove the water of condensation, the discharge pipe carries an appendage provided with a small clack valve, which yields automatically when the water reaches a height of about three inches.

The expansion cylinder is provided with cocks, R R', that permit of isolating it from the small cylinder, and of converting it into a compressor for forcing the air that it contains into the reservoirs, and thus performing the office of a brake.

Over the boiler there is a receiver, which contains water and which communicates with the cylinder through a pipe with a flaring end containing three small apertures, so as to introduce air into the cylinder during the suction.

Another receiver, placed under one of the seats, contains hot water designed to feed the boiler. This reservoir communicates with the compressed air reservoirs, so that it is only necessary to turn on a cock in order to feed the boiler.

Such, in a few words, is the general arrangement of the motor. In the transmission of motion there is nothing peculiar.—*L'Industrie Moderne.*

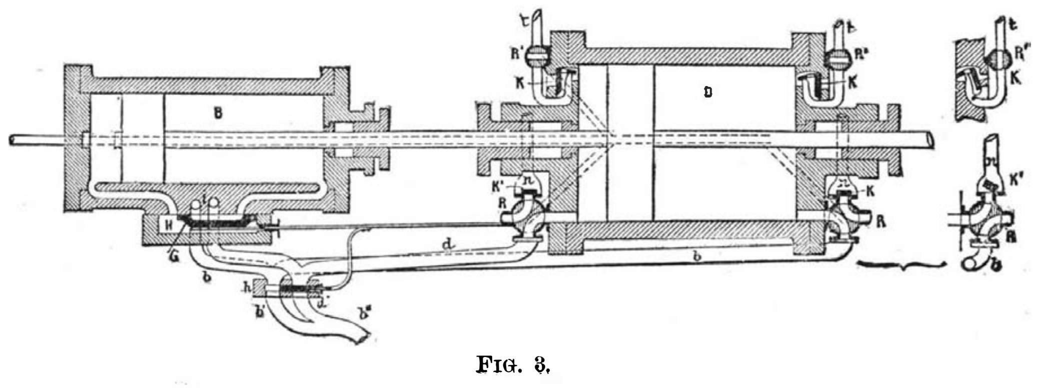


FIG. 3.

## A STEAM PROPELLED TORPEDO.

THERE is at the present time undergoing consideration by the British Admiralty authorities a system of propelling traveling torpedoes by means of steam instead of by compressed air, as now generally employed. This system has been devised by Mr. Edward C. Peck, who is engaged in the constructive department of Messrs. Yarrow & Co.'s torpedo boat yard, at Poplar, and it is not without merit. The torpedo is of the usual Admiralty pattern outside, the dimensions being 14 ft. long by 14 in. diameter, and it will carry in the forward part an explosive charge of 100 lb. of gun cotton, together with the firing apparatus. The shell will be constructed of metal, and will be sufficiently strong to resist the external pressure of the water and atmosphere when a vacuum is formed within it. At about the center is a hot water reservoir 4 ft. long and 11½ in. internal diameter, and capable of withstanding a given pressure. This reservoir will be surrounded by a coating of non-conducting material ¾ in. thick, and between the outside of this and the skin of the torpedo will be a space of ⅜ in. The reservoir is to be charged with about 160 lb. of hot water, taken from the main boiler of the torpedo boat or other vessel from which the weapon is to be discharged. The water will be transferred very rapidly, at a pressure of about 400 lb. per square inch, by means of a tube fitted with the necessary inlet and outlet valves, and there will be means for raising the temperature of the water, if necessary, during its transfer from the boiler of the boat to the reservoir of the torpedo. The charging operation will not occupy more than half a minute, and it is calculated that the torpedo will keep steam at the pressure necessary for driving her engines for at least an hour after it has been charged. The quantity of water carried will possess sufficient sensible heat to supply the propelling engines with steam of a slowly decreasing pressure during the run of the torpedo. The space between the reservoir and the skin of the torpedo, as also the portion of the space in the body of the torpedo not otherwise occupied, is utilized as a surface condenser for the steam after it has done its work in the engines. By this means the weight of the torpedo will be precisely the same at the close as at the commencement of the run. The torpedo will be fitted with engines of 60 I. H. P., and capable of propelling it through the water at a speed of 32 knots or about 37 miles an hour. It will be fitted with the usual fins, rudders, and regulating apparatus, to insure its traveling at any required depth and in any desired direction. The advantages of a steam driven torpedo would appear to be very considerable. In the first place, weight is saved in the torpedo itself, and, the pressure being only about one-fourth of that in the Whitehead torpedo using compressed air, there will be no difficulty in keeping all the joints and connections tight. In the next place, compressed air will only give a three-quarter minute run, while it is calculated that steam will give a run of a minute and three-quarters. The speed with compressed air is 24 knots and the average range 600 yards, while with steam Mr. Peck reckons on a speed of 32 knots and a range of 1,800 yards. The adoption of this system would result in a

considerable saving, inasmuch as the costly and complicated air compressing machinery would be superseded by a cheap and simple charging apparatus, consisting only of a tube and valve connections with the boiler and the torpedo.

## STIFFENED SUSPENSION BRIDGES.

I ANNEX drawings of a peculiar type of suspension bridge recently adopted by the public works department in the Darjeeling district, over the rivers Kohil and Pool Bazaar, each 70' clear span, of which Messrs. A. W. V. J. Main & Co., of Glasgow, are the manufacturers.

In constructing suspension bridges of the ordinary type for passenger and light traffic, the difficulty always presents itself of obtaining a structure presenting sufficient stiffness without a disproportionate increase of weight. The plan usually adopted is to introduce side girders, and this arrangement gives structurally a quite satisfactory result, but at an expenditure of weight which, especially in small bridges, tells seriously on the cost.

In the bridge now submitted, stiffness against deformation and vibration in a vertical plane is secured by bracing together the upper curved and the lower horizontal member of the bridge frame. In this way there is given to the structure a stiffness approaching that of the ordinary girder bridge, while at the same time by the disposition of the bracing it is so secured that both the upper and lower members shall be subjected to tensile stress.

There is one particular distribution of the load which causes an exception to this latter statement, due provision for which has been made in the design.

The stresses on the diagonal bracing, moreover, are very small, owing to the fact that the stress which comes on the ordinary girder with horizontal booms is largely taken up by the curved upper chain in this pattern bridge.

The distribution of stress in Garson's patent bridge is therefore entirely different from that of the ordinary suspension bridge, and manifestly the structural arrangements will not bear comparison with other structures in like respect.

Speaking generally, the distribution of stress in this bridge is as follows:

*Upper Chain.*—Stress at center equal to zero increases toward piers when it reaches a maximum.

*Lower Horizontal Member.*—Stress at abutments equal to zero increases toward center of bridge, when it reaches a maximum.

*Diagonal Bracing.*—Stresses almost the same horizontal and of small amount.

The bridge is hinged at the center, so that it can rise and fall as a whole with variations of temperature.

The piers are constructed of wrought iron or steel and are of H shape, or other suitable section, and being hinged at the base and connected at the summit, the stress on them is always axial. Indeed, the function of the piers is simply that of struts which, being hinged at the ends, are subjected to no bending moment.

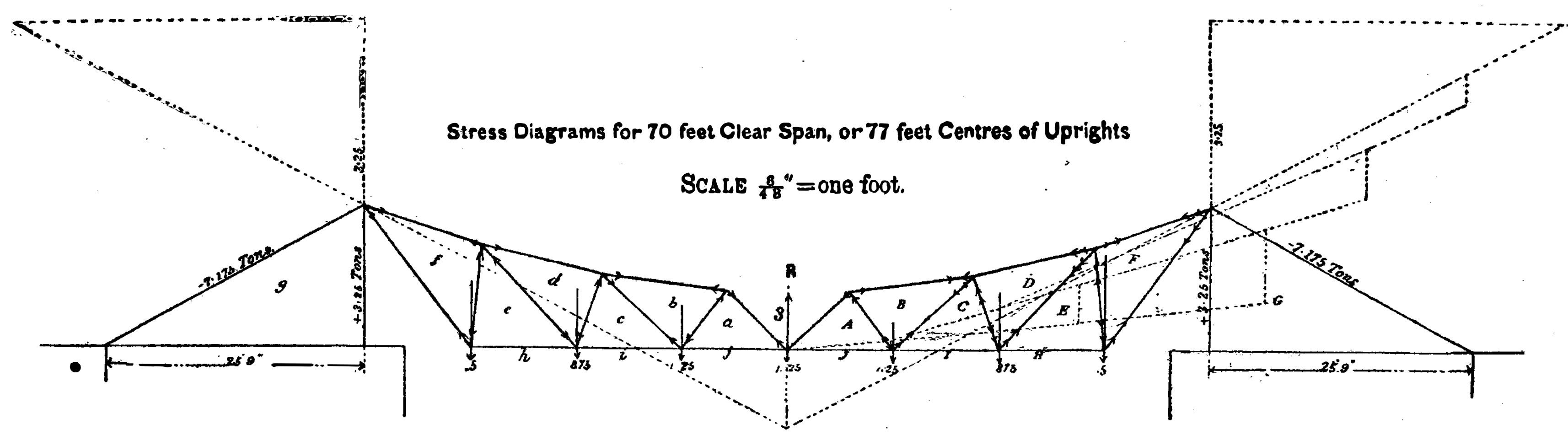
Consequently, the stress on the foundations is purely of the nature of a vertical load. The foundations, therefore, should present no unusual difficulties, if indeed they are not more simple than in the case of an ordinary suspension bridge.

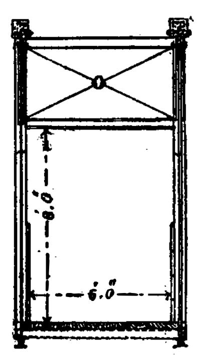
What is claimed for the design is that, in every point, it fulfills the most stringent conditions of engineering efficiency, while the weight and cost are much lower than for a corresponding bridge of the ordinary principle.

Each bridge to suit 70 feet clear span, between abutments, consists of 6 feet wide clear roadway of 4" thick planking running longitudinally on, and fixed with bolts to, 18 rolled cross girders 4" × 1¾" H section. These are supported by *double* channel iron longitudinal girders 4⅛" × 2$\frac{1}{16}$" at each side, supported by ties, struts, and suspension chains, as shown in drawing, carried on pillars at each end of bridge. Each pillar consists of one rolled girder column 8" × 5" H section, with cast iron socket and anchor bolts for fixing into concrete foundation; cast iron "head piece;" and flat iron back ties connecting to steel wire rope 1⅛" diameter, anchored with cast iron plate at back of large concrete block having shackle for adjustment. The ¾" diameter wind ties run diagonally from alternative cross girders as shown by "part plan" in drawing. The handrail on each side of bridge is 4 feet high, and formed with tube rail at top 1¼" external diameter, having three lines of ¾" diameter round bars below, ditto running through 2½" × 2½" × ⅜" angle iron standards, at about 4 feet centers apart, bolts, nuts, etc.

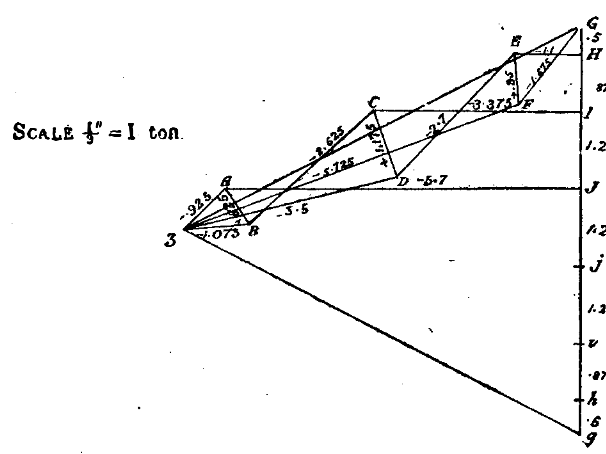
From the general plan for a bridge of 70' span, on Mr. Garson's plan, and the diagram of strains for the same, furnished herewith, the essential features of the design and the mode of distribution of stress in the different members of the frame will be easily understood, and I feel sure that a thorough inquiry into the distinctive features of the design will satisfy engineers of its perfect safety and of the advantage it presents in respect of economy and simplicity of construction.

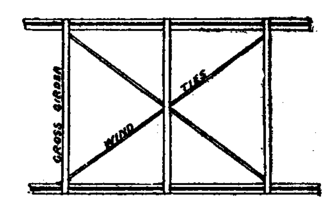
The cost of one of these suspension bridges, 70' span × 6' wide, delivered in Calcutta, is £125, the weight being 137 cwt.—*Indian Engineering.*




*Cross Section.*

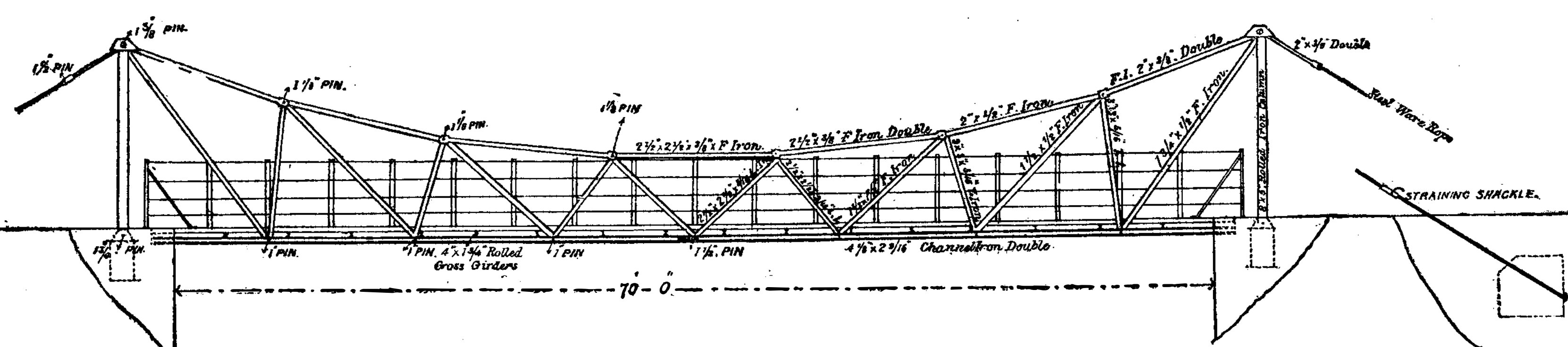



*Part Plan Showing Wind Bracing.*

**Dead load = 8 tons.**

**Live load = 6 tons on 4 Central Bays.**




*Elevation.*

GARSON'S IMPROVED SUSPENSION BRIDGE.

## GIRDERS AND BEAMS.

THE second of the present course of free lectures at Carpenters' Hall, London Wall, was recently delivered by Professor Alexander B. W. Kennedy, M. Inst. C. E., of University College, Gower Street, the subject being "Girders and Beams." It was illustrated by blackboard drawings and experiments with models, and was attentively followed by the large audience present. Mr. Preston, past master of the company, occupied the chair.

The lecturer remarked in his opening observations upon the comparative complexity of beams, which were subjected to every kind of strain, and urged the importance to every workman of understanding what these strains were, and the manner in which they acted. When a piece of material was strained in a structure, the force applied usually fell under one of four classes: (*a*) tension, as exemplified in a tie; (*b*) compression, as in a strut or column; (*c*) torsion or twist, as in a shaft; and (*d*) a transverse strain, the last being that which applied to a beam and girder. In the first and second cases the load was supposed to be applied in the direction of the length, and the position of loading was always supposed to be the same—axial. In the first case, that of tension, depth and shape were of little importance, the area being the consideration, and the result of applying tension was to pull the material straighter. In compression, length and shape were all important, and also the method of fixing the ends, as the tendency was to buckle.

Torsion was not of much importance in a structure; the resistance to twisting off in a shaft depended on where the force was applied and where it acted, or the leverage. The effect was the same if a ton force were applied at the end of a lever one foot long, or half a ton at two feet distance, and two tons at six inches off; the strength of the shaft depended on the resistance to force plus the leverage applied to twist it, and these combined forces were known as the "moment," while the resistance was reckoned in multiples of the two strains exerted, in foot-tons or inch-pounds, as the case might be.

A beam resembled a shaft in this respect—it was not broken by a force simply, but by a force acting in a particular position. In some way, therefore, the strength of a beam depended on its load and the position of that load measured from the supports. By

loading a model of a cantilever, Prof. Kennedy showed that it broke away from the support when overweighted as the result of leverage, which acted proportionally to the distance of weight from the support. The lecturer demonstrated that why a loaded beam did not fall was because of supporting force beneath, which he showed to be just as real as the loading force. A model of a beam hung from springs showed the same principle applied to a suspended beam, and a weight hung below registered ten pounds, whether in the center, as indicated by a strain of five pounds on each spring, or near one end, shown by strains of one pound and nine pounds respectively. The combined pressure upon the beam and resistance to that pressure in the supports occasioned the bending in a beam, the characteristic strain which it underwent.

We could ascertain the strength required in a beam if we could find the bending moment of the forces on it, and this was a very simple arithmetical problem—viz., to multiply half the length by half the load, expressing the result in foot-pounds or whatever unit was taken for each force in the case. This applied to a beam loaded at one point, say, for convenience, in the center. Where the beam was equally loaded throughout its length, as in a floor, only half the tendency to bend was apparent as where the load was concentrated in the center. So much for outside forces. But it was important to consider what was going on within the beam while it was being bent. If we pulled at the ends of a tie rod, it stretched a little and then pulled back to an equal degree, the pull within being known as stress. It was just the same in the case of a beam; the particles of wood or metal resisted change of position, and there was a stress exerted in the beam balancing the outside forces.

As these outside forces or strains formed a moment whose action was measured by the amount of this resistance, the internal forces or stresses must also have a moment. This could not easily be shown in the model of a beam; but in the cantilever, cut from its supports, it would be seen that a prop beneath or corbel would not retain it, a wire from above allowed the free end to hang down, and was insufficient, and a roll of paper to resist torsion was needed, in addition to a corbel below and a wire above, to enable it to be retained in position. The several strains on these members could be easily calculated. The lecturer next showed a thin lath, through which a number of strips of wood had been run at regular intervals, projecting above and below. On weighting the middle of the lath it bent downward, and in doing so the ends of the pieces of wood above were brought nearer, while those below were thrust further apart. These experiments proved that compression was going on at the top and tension at the bottom; and as the extent of these forces increased directly with the distance from the center, it was evident that there was a neutral line at which the strains were least.

This neutral line always existed, although if the beam were unsymmetrical it was not exactly in the center. At this point the material was neither strained by tension nor compressed. Near it the material was but little strained, and only the material at the outside surfaces was much strained. It followed from this that if a beam were of the same dimensions throughout, as a joist, there was a great waste of material by putting it where it was doing little good. If, leaving the upper surface subject to compression and the lower surface subject to tension, the sides were trimmed off, the beam was weakened, but nothing like in proportion to the weight lost. It was possible to remove thirty per cent. of the weight of a beam, and only to weaken it by five per cent. This was because the strength of a beam depended on the moment of resistance to leverage of the compression and the tension, and the further we could separate these forces from each other, the greater the resistance to their strain.

It should be the aim of those who designed and made beams to economize the material, for useless weight meant useless expenditure. In the case of the joist or other wooden beam, no practical step could be taken, for the labor of chamfering away the sides brought no compensation in value of material; but in a built-up structure, or one made of wrought or cast iron, the conditions were different, and it became an easy task to save loading the structure with nearly useless material. In a built-up or iron structure, by replacing the material cut away from the sides of the beam on the top and bottom surfaces, the original weight was retained; but the strength might, perhaps, be doubled. Why was this? Because the material was utilized to greater advantage by increasing the leverage of the tension and the compression.

This principle was at the foundation of all modern beam designs in metal—the material was concentrated in two masses as far apart from the center as possible. We had thus the typical ⌶-shaped section of rolled joists, and this when simple was regarded as a beam, and when more complex as a girder. The top and bottom of the ⌶ were known as flanges, and the intermediate stem as a web. If we wanted to know what a rolled joist in wrought iron of a given span would safely carry, it was easy to make an approximate guess. For this rough and ready purpose the resistance to tension of a wrought iron rolled joist might be reckoned at twenty tons per square inch, of which one-fourth, or five tons, might be taken as a safe working load. The web for this calculation might be disregarded. We must first find the area of flange, say 4 sq. in., and next the depth of web between centers of flanges, say 10 in.

The safe load having been settled at one-fourth, or five tons, then the area of 4 sq. in. multiplied by the depth, 10 in., equaled 200 inch tons. Then if the span were 20 ft., and we wanted to find the possible uniform distributed load, we reduced the 20 ft. to 240 in. and divided it by 8, the resultant being 30. This, divided into the 200 inch tons, gave $6\frac{2}{3}$ as the safe uniform distributed load, or half this ($3\frac{1}{3}$ tons) as the load applied in the center, the breaking load being $26\frac{2}{3}$ tons. The next practical question was, What sections of rolled wrought iron joists were available to us that fulfilled the necessary conditions of concentrating the metal at the top and bottom? The L and T shapes were clearly not suitable. The [, or channel iron, was useful, and the I and ⌶ forms still more so. The former could be ordered anywhere up to about 16 in. depth. The two ⌶ sections placed vertically above each other were often employed for convenience; but the double flanges in the center did no work, and simply meant useless material, and the whole was only about twice as strong as one joist of the same size.

Where the two ⌶ joists were placed side by side and stiffened by means of an additional place above and below, connecting them at top and bottom, the material was utilized in the best way; but it should be remembered that every rivet hole in each plate must be reckoned as an absolute loss of strength, and the whole areas of these holes must, therefore, be deducted from the available flange surfaces. Where the dimensions were too large for single joists, they were built up with plates and L joists at the tops and bottoms, and their capacities of carrying loads were as easily and certainly calculated as the simple example they had worked out. This applied to wrought iron; but where cast iron was used, it was necessary to bear in mind that the material offered a much greater resistance to compression than to tension. The relative proportion of web and upper flange remaining the same, it was requisite to extend the lower flange, and hence a cast iron joint assumed the ⊥ shape.—*Building News.*

## MAGAZINE AND REPEATING RIFLES.

THE theater of the Royal United Service Institution, London, was densely crowded lately, to hear Captain James lecture on the question which at the present moment excites so much attention in all the military circles of Europe.

In his opening statement, the lecturer asks what it is we seek to obtain from the magazine or repeating rifle. Surely the rapidity with which a good form of single loader can be fired will suffice. With the Soper rifle forty-three well directed shots have been fired in a minute, and what more can be desired or required in war? But this argument does not really deal with the true reason for their introduction. As stated by Captain James himself in the same place, seven years ago, "The future undoubtedly lies with repeating rifles. The advantage of this form of weapon is that it enables a *sudden* shower of bullets to be poured in at a moment when increased intensity of fire will decide the victory."

This blinding rain of bullets at a critical moment is to be obtained from the magazine rifle alone, and it is for this reason that the nations of Europe are spending millions of money in the rearmament of their troops. There is also the second advantage of the confidence and moral support given to the soldier, who feels that he has a reserve of power constantly at hand.

In a properly constructed magazine rifle, the time taken to convey the cartridge from the pouch and press it into the bore is eliminated. Drawing back the action cocks the rifle, throws out the empty case, and brings the fresh cartridge to the mouth of the chamber, while the act of closing the breech presses it home.

Conceive for a moment the effect when, of two lines holding one another in close action, one is suddenly enabled to quintuple its fire rate. To sentries, also, and small reconnoitering parties of cavalry, the repeating rifle would be of the greatest assistance. In the American civil war it was said that one man armed with the Spencer was equal to five with the ordinary muzzle loader, while in the Russo-Turkish war the Winchester did good service to the Turks.

The lecturer reviewed the measures taken by the European powers to provide an efficient magazine rifle for their armies. As usual, Germany was in the van of progress—at least, in order of time. Immediately after the war of 1870–71, experiments were commenced —or rather, resumed—which resulted in the needle gun being superseded by the Mauser rifle model "M 1871." A few years later endeavors were made to increase its rapidity of fire, and it seemed at one time likely that the heavy Lowe magazine, which is of a horseshoe shape encircling the breech, would be adopted, but its clumsiness prevented its introduction. After various trials, the Mauser magazine rifle was adopted. It is now in the hands of five army corps, and probably before the summer will be the weapon of the whole German army.

As the name "M 71-84" indicates, it is the breechloading rifle of 1871 with the addition of a magazine under the barrel and a mechanism for raising the cartridges to the chamber. The magazine holds eight cartridges, which, with one in the "elevator" and one in the chamber, makes ten in all. By pushing forward a stop on the left side the magazine action can be shut off, and the rifle turned into a single loader. The cartridge is the same as for the M 71 weapon, but experiments have been made with an increased charge of compressed powder, and a lead bullet with a thin covering of steel. This would raise the muzzle velocity, increase the penetration, and make the trajectory flatter. But this rifle is faulty in having the magazine under the barrel. When filled, it is a very heavy, awkward weapon, and the balance is altered each time it is fired.

In France no definite solution has yet been arrived at, but the Lobel-Gras repeater will probably be adopted, having eight cartridges in a magazine under the barrel, and, in the case of new arms, a reduced bore of about 0·307 in. The French navy have for some years been armed with the Kropatschek magazine rifle, which does not materially differ from the Mauser, except in being rather more complicated. The magazine can hold seven cartridges.

Austria has definitely adopted the Mannlicher rifle, which presents two peculiarities worthy of special notice. The Werndl barrel and ammunition is retained, but the block for closing the breech has been replaced by a very ingenious bolt, which is opened and closed by a straight backward and forward motion. This can be worked much more quickly than one in which there is also a side turn for locking the bolt, and the rifle need not be removed from the shoulder till the magazine is empty. The cartridges are carried by the soldier, packed in small tin frames holding five rounds. One of these frames is placed in the magazine, which is situated under the shoe or bolt chamber, whence the frame falls automatically when empty. The frame weighs about the same as a bullet, 385 grains, and costs less than a halfpenny. The rifle cannot be fired as a single loader when these frames are used. This arm appears very superior to the Mauser. Like that rifle and the French Kropatschek, its caliber is 0·433 in.

In Italy it has been determined to alter the Vetterli bolt gun system known as the Vitali. A magazine is fixed under the shoe, in front of the trigger guard, into which four cartridges packed in a cardboard box are pushed from above. This is avowedly only a temporary expedient, pending the introduction of an improved weapon. The alteration costs a very small sum. Like the Mannlicher, this rifle cannot be used as a single loader.

Switzerland has for some years past had the Vetterli magazine rifle, with a rather complicated action, somewhat on the Winchester principle. The magazine under the barrel holds eleven rim fire cartridges. The arm is very heavy, weighing 10 lb. 8 oz.

Russia has introduced the Evans rifle into her navy, which carries the very large number of thirty-five cartridges in a magazine in the butt, but is not likely to be adopted in the army. Pending the introduction of a new arm, it is stated that a form of attachable magazine has been devised for the Berdans, which can be fixed to that rifle in less than ten minutes.

Sweden has for some time had the Jarman magazine rifle. At first the magazine was a box affixed to the right side of shoe at an angle of about 30° to the vertical, but this has been replaced by a tube under the barrel holding eight cartridges. A specimen of the original arm was exhibited.

Portugal has recently adopted a magazine arm, the Guedes rifle, distinguished from all the others mentioned by a small bore, 0·323 in., and high initial velocity. The magazine and breech action are the same as in the Kropatschek.

As regards our own country, it has been resolved to manufacture a limited number of two of the magazine rifles which have been experimented upon by the special committee appointed by the war office, and to issue them to the troops for an extended practical trial, before definitely adopting a new pattern for the whole army. These are the "improved Lee" and the "Lee-Burton," which were placed at the disposal of the lecturer by the kindness of the secretary of state for war. The former has the Lee box magazine under the breech, in front of trigger guard, but it is fixed instead of being detachable, as in the original Lee repeater. The "Lee-Burton" has the magazine fixed to the right side of the breech, and therefore not so much out of the way as in the Lee.

The lecturer exhibited and explained the action of the above rifles, excepting those adopted by France and Russia, as well as the Pieri, the Schulhof, Owen-Jones, Bethel-Burton, and Winchester magazine guns. The Pieri, with a caliber of 0·323 in., like the Portuguese Guedes, is said to give a muzzle velocity as high as 2,057 ft. per second. The Schulhof has a central magazine holding ten rounds, and, like the Mannlicher, a straight bolt action. The Owen-Jones is distinguished as being the only block action magazine rifle exhibited, which is worked by a simple backward and forward motion under the stock.

The fixed magazine is preferred by the lecturer to the detachable, as less liable to be lost in the heat of action, when also it would be difficult to affix fresh magazines.

Captain James dwelt upon the chief desiderata in the most improved form of military rifle. Putting aside the great questions of simplicity and durability of mechanism, it should first shoot well and closely up to 1,500 or 2,000 yards; secondly, have a flat trajectory within the decisive fighting zone of say 600 yards. These two conditions require:

A. A high proportion of weight of bullet to its area of cross section (*i. e.*, $\frac{D^2}{W}$ to be kept as low as possible).

B. A high muzzle velocity.

To fulfill these conditions without unduly increasing recoil, or the weight of the rifle, it is necessary to have a long light projectile, or, in other words, a small bore is a necessity. Experiments in this direction have been followed out by Lieutenant-Colonel Bode in Germany and Major Rubin and Professor Hebler in Switzerland. They have likewise all determined that a lead bullet covered with a thin shell of harder metal —copper or steel—is far preferable to lead alone. It is claimed that this projectile does not lead the grooves, as is likely to be the case with a long soft projectile driven at a high speed, nor does it wear the rifling, as would a bullet of hardened metal, the thin steel or copper coating being pressed into the lead of the bullet. The former seems preferable, and a Hebler rifle has fired 1,500 rounds with steel coated bullets without the least sign of wearing the rifling. The steel envelope polishes out the bore every time, and removes fouling, so that no lubricator is required. Tables were exhibited showing the remarkable results of firing this projectile. Fired from the Mauser rifle, it penetrated through two blocks of beech wood, each $3\frac{1}{2}$ in. thick, and eleven deal planks.

The lecturer said he would like to see trials made in this country of calibers smaller than the new Enfield-Martini barrel of 0·4 in. The diagrams of trajectories exhibited showed this rifle to have a flatter trajectory than any European military arm, except possibly the Guedes, but Professor Hebler's rifle slightly beat it in this respect, being quite 2 ft. lower at its highest point, which was about 30 ft. in a range of 1,000 yards. He suggested a bore of 0·32 in., with a bullet of 336 grains and a powder charge of 90 to 100 grains as a desirable combination.

To the objection usually made that long bullets from small bores are much more affected by a side wind, it was urged that, in the field of battle, lateral deviation is usually of far less moment than correct range and flatness of trajectory. The conditions are very different from those of match shooting. Besides, the soldier can only carry a certain weight, and long range fire, breech loading, and magazine arms all point to increased expenditure of ammunition. Therefore, the soldier must carry more rounds, and the individual cartridges should weigh less.

Assuming that we have a weapon which will hold five or more cartridges in the magazine, that the latter can be easily reloaded, and also that the rifle may be used as a single loader, how should it be employed?

On the offensive, fire should be by volleys alone; the final rush should be prepared by the use of the magazine, which should be reloaded the moment the position is carried. On the defensive, the same principle should be followed, but the magazine may possibly be earlier and more often employed, *i. e.*, at long ranges when it

can be rapidly loaded, and at advancing troops during their rushes, when they are more fully visible. In either case, the magazine should be chiefly for close combat, and for the decisive stage when its proper employment may decide the issue.

The introduction of repeaters will, to a certain extent, increase the expenditure of ammunition, but, as a practical fact, this increased expenditure will not so much be a necessity of magazine rifles—properly used—as it will be due to the growing tendency, previously pointed out by him in this institution, of utilizing long range firearms. Having rifles of accuracy at long ranges, it seems indeed foolish to restrict their use to short distances. But the possession of such weapons demands careful training, both of officers and men.

In the discussion which followed, several gentlemen took part. Colonel Arbuthnot, superintendent Royal Small Arms Factory, agreed with the lecturer that the tendency was in the direction of small bore rifles, but there were other considerations to be taken into account besides flatness of trajectory. The diagrams exhibited were a little misleading in this respect, as the apparent ground line was really the line of sight.

For military purposes, the barrels must be strong enough to stand rough usage, and there was evidently a limit to reducing the bore by increasing the thickness of metal, and consequently adding to the weight of the arm. Also the size of the bullet must be considered. He did not think that the introduction of magazine arms would lead to a lavish expenditure of ammunition, but rather that there would be a tendency to husband it. It was to be trusted that the practical trial of the two selected rifles would eventually result in our being possessed of the best repeating rifle in Europe.

With reference to the number of shots given as fired from a Soper rifle in a minute, a recent number of the *Avenir Militaire* gives twenty-seven well directed rounds as having been fired from a French Gras rifle in the same time. *Engineering* does not think any military single loader in Europe attains the rate of fire mentioned for the Soper by Captain James—more especially if manipulated by the ordinary infantry soldier.

[Continued from Supplement, No. 590, page 9428.]

## PRINCIPLES AND PRACTICE OF ORNAMENTAL DESIGN.*

By Lewis Foreman Day.

### Lecture IV.

#### NATURAL FORM AND ORNAMENTAL TREATMENT.

There is no disputing the bias of the natural man in favor of nature. The Etruscans and the Moors, almost alone in the history of art, appear to have been content with ornament which was ornament pure and simple. It is not too much to say, even in these days of affected interest in things decorative, that the average Englishman neither knows nor cares anything about the subject. In most cases he is absolutely out of sympathy with it; he has probably even a sort of contempt for the "ornamental," as something opposed to the "useful," which he so highly esteems, never so much as apprehending the fact that ornamental art is art applied to some useful purpose.

The ornamental forms he most admires are the forms most nearly resembling something in nature; abstract ornament is incomprehensible to him. He begins to take a feeble interest in Greek pattern work only when he sees in it a likeness to the honeysuckle. Show him some purely ornamental form, and it is neither its beauty, nor its character, nor its fitness that strikes him; he is perplexed only to know what it is meant to represent, as though every form of ornament must have its definite relation to some natural object, and therein lay its interest. I say a definite relation, because a relation there must be; and that relation was at one time in some danger of being overlooked. The reaction against the artificialities and affectations of art which characterized the early part of the present century came none too soon, and we owe all gratitude to the men who led opinion back again to the forgotten, grass-grown paths of nature.

But, now that the peril which threatened is well passed—so far passed that whatever was traditional in art is, in its turn, in danger of becoming extinct—it is time we bethought ourselves that not all of these traditions were pernicious, perhaps none of them altogether so; for whatever of perversion or degradation they may have undergone, they represent the embodiment of artistic experience during all time and among all nations. The masters, old or new, must be presumed to have known something.

If there was at one time some fear of artificiality in art, the danger now lies in the oposite direction of literalism—a literalism which assumes a copy of nature to be not only art, but the highest form of art; which ignores, if it does not in so many words deny, the necessity of anything like art on the part of the artist, accepting the imitative faculty for all in all.

Were I to venture upon the sweeping assertion that all art whatsoever is and must be conventional, I should very likely be laying myself open to the just rebuke that I was judging all art by my own decorative standard; but with regard to ornament, I have no hesitation in saying that more or less conventional it must be, or it would not be ornamental. Not, of course, that the ornamentist denies in the least the supreme beauty of natural form and color, or thinks for a moment to improve upon it, as they seem to imagine who taunt him with the question, "Do you flatter yourself you can surpass nature?" "Paint the lily?" and so on. Only he recognizes the impossibility of even approximately copying anything without sacrificing something which is more immediately to his purpose than any fact of nature—namely, consistency, fitness, breadth, repose—and is content, therefore, to take only so much of natural beauty as he can make use of. He regulates his appetite according to his digestion. This self-denial on his part is not by any means a shirking of the difficulties of the situation. In art nothing is easy, except to such as have a natural faculty that way. It is not easy to every one to make a striking study from nature, but it does demand ability of lesser kind to succeed in that comparatively elementary effort than to paint a picture in which there is design, unity, style, and whatever else may distinguish the work of a master of the Renaissance from that of a student of to-day.

In like manner, the mere painting or carving of a sprig of foliage is within the reach of every amateur; but to adapt such foliage to a given position and purpose, to design it into its place, to treat it after the manner of wood, stone, glass, metal, textile fabric, earthenware or what not, demands not only intelligence and inborn aptitude, but training and experience too.

Fig. 21.

It is the easiest thing in the world to ridicule the conventional (if we are to use that much abused term), but it would be an awkward moment for the derider if he were asked to pause a moment in his merriment, and point out a single instance of even moderately satisfactory decoration in which a more or less non-natural treatment has not been adopted. The fact is, the artist has not yet arrived at a point where he is able to dispense altogether with art.

Those who most keenly feel the need in ornament of a quality which the modern nature worshiper delights to disparage, will be inclined to pray that they may be preserved from some of their allies. There is a class of ornament (grown, I believe, originally in the vicinity of Kensington) which appears to have originated in the idea that you have only to flatten out any kind of natural detail, and arrange it symmetrically upon arbitrary lines, and the end of ornament is achieved. But decorative design is not so easy as all that. To emasculate a natural form is not to fit it for ornamental use, and to distribute detail according to diagram is not to design. That may be conventional, but it is not the

Fig. 22.

kind of convention I am upholding; one touch of nature is worth all the mechanical and lifeless stuff of that kind that ever was done.

One hopes, and tries to think, that this kind of thing is dying out, if not quite dead already; but then one flatters one's self so readily that what has been proved absurd must be extinct, or moribund at least, until perhaps an enforced stay among the Philistines—say in some lodging house parlor—brings us face to face with the evidence how very much it is alive. We have only weeded it out of our little garden plot; about us is a wide world where it rampant. There's no hiding it from ourselves that there's life in the old dogma yet. And it is still as necessary as ever to deny its claim to represent the due adaptation of natural forms to decorative needs. It is no more fair to take this ridiculously childish work to represent conventional design than it would be to instance the immature studies of a raw student as examples of a naturalistic treatment. Compare the best with the best. Compare the ceramic painting of Sevres with that of ancient Greece, China, or Japan; compare the work of Palissy with that of the potters of Persia and Moresque Spain; compare the finest Aubusson carpet with a Persian rug of the best period; compare the earlier arras (such as we have at Hampton Court) with the most illusive of modern Gobelins tapestry; or the traditional Swiss wood carving on the chalet fronts at Meyringen and thereabouts with the most ingenious model produced in the same district for the English and American tourist (who ought to know better); compare the mosaics which make glorious the domes of the baptisteries at Ravenna with the unimpressive display of Correggio (great artist though he was) at Parma; compare the peasant jewelry of almost any country except our own (we never seem to have had any) with the modern gewgaws which have taken its place—and who would hesitate to choose the more conventional art?

I am not contending for the word conventional, but for that fit treatment of ornament which folks seem agreed to call by the title, more especially when they want to abuse it. By whatever name it is called, we cannot afford to let go our hold of that something which distinguishes the decorative art of the palmiest periods, and of the most consummate masters, from the crude attempts of such as have not so much as grasped the idea that there is in art, properly so called, something more than a dishing up of the raw facts of nature.

Work as nearly natural as man can make it, though not in itself decorative, may be at times available in decoration. But forms denaturalized by men alike ignorant of the principles and unskilled in the practice of ornament, and more than half contemptuous of the art to boot, are of no interest to any one but their authors, if even to them. Nature and art are not on such bad terms that to be unnatural is to be ornamental.

The purport of my last lecture was to show that ornamental forms should by rights be determined by the position, purpose, use, material, and mode of execution of the object in hand. It follows that these considerations must determine equally the modification of such natural forms as the designer may from time to time see fit to adopt.

Here, again, all modification must be according to the conditions of the case, not according to precedent, unless, indeed, we find that the most reasonable lines to work upon have been laid down for us already. Occasionally this may be so. I do not quite see how one is to improve much upon the best Greek rendering of the acanthus or of the ivy. So, again, the Japanese have gone far to exhaust the resources of the bamboo, the almond blossom, the peony, and certain other plants more peculiarly Oriental. Yet even in such instances (although it may well be doubted whether we can ever again treat such forms as well as they can be treated, without recalling the Greek or Japanese treatment of them), the least we can do is to try whether we cannot develop those forms, instead of merely adopting them. In very many instances, to some of which I shall allude by and by, the accepted treatment is anything but adequate, that it should be allowed to lord it over our design, and say "thus far" to our invention.

The excuse, and the only excuse, for accepting time-honored forms is not that they are time-honored, but that they are the best, and we cannot anyway better them. Even then, whoever is not quite without initiative of his own will always believe in the possibility of some new thing, or, at all events, something not so egregiously trite as the venerable models of the schools. And though he fail to equal these, as well he may, we have a right to expect in his sincere expression of himself a freshness and vitality which no mere archæological reconstruction can ever have. The artist may be excused if he believe that it is neither natural fact nor antiquarian accuracy that he has to aim at, but design. Art is not quite such an artless thing as some would have us suppose.

Granting the intimate relation between nature and design, it must be granted also that nature is the starting point and not the end of art ornamental. The grace, the growth, the flow of line, the tenderness of color, all the subtlety of suggestion, which so delight us in ornament, would not have been evolved from man's imagination apart from natural influences; but neither does nature provide for us ready-made ornament—or our occupation would be gone. Indeed, according to the use we make of nature, it is a help or a hinderance to us in design. Owen Jones went so far as to assert that in proportion as ornament approached to natural forms, it had less claim upon us as ornament. In that I think he went too far, much too far. It might with equal truth be contended that only in proportion as it came near to nature had it any claims upon our sympathy at all. That does not happen to be my opinion, but I am afraid it is the opinion of by far the larger proportion of Englishmen.

But how on earth, it may be asked, can nature be in any case a hinderance to the ornamentist? Well, mainly in the way it diverts his attention from the ornamental purpose. It has a way of claiming too much consideration for itself; and the artist has a way of yielding to the seductions of a mistress, not the one he has, so to speak, sworn to love and cherish.

The designer can hardly make too many studies from nature, but he can very easily make bad use of them. He can design quite freely only when the burden of natural fact is so familiar to him that it ceases to be a burden. An occasional reference to his studies, or to nature herself, may be refreshing enough; but to design with either in front of him, is to design under conditions of restraint not favorable to ornament.

There are two kinds of ornamental treatment, the one in which a natural type is treated ornamentally (Fig. 21), the other in which an ornamental form, suggested possibly by the material or tool employed, grows under the workman's hands into the semblance of something remembered in nature (Fig. 22). Nature modified by considerations of ornamental propriety, and ornament modified by our familiar acquaintance with nature, end in something of the same kind.

But it is with the deliberate adaptation of natural forms to the purpose of ornament that we have to do just now. The degree and kind of modification neces-

* A series of four lectures recently delivered before the Society of Arts, London. From the journal of the society.

sary cannot be arbitrarily prescribed; it will depend entirely upon the conditions of the case. The natural element may be almost eliminated in the process of adaptation, as it is to a great extent in Fig. 21, or it may remain paramount. The degree of modification needed, or the degree of naturalness admissible, will depend, not only upon the aim of the artist, but also upon the arbitrariness or naturalness of the composition. A strictly formal arrangement involves an equally formal kind of foliation, while natural leaves and flowers call for proportionately natural growth in the design. If, for example, it were a question of clothing a geometric skeleton with foliage, the form of the skeleton would determine the formality of the leaves. If, on the other hand, some natural form of leaf or flower were peremptory, it would logically determine the lines of the design. Rendering and arrangement should. that is to say, naturally be in keeping. But this simple principle is far from being sufficiently borne in mind. One often sees a kind of cast iron flower, reminding one of a preternaturally prim rosette, or of a catherine wheel, perhaps, with firework foliage, together with stems and stalks that have some pretensions to growth. Or you may see leaves and flowers altogether as natural as can be springing mechanically from quite arbitrary lines.

The Japanese, who render the forms of leaves almost naturally, make them grow from the stalk; the Greeks, at their best, made leaves and their attachments alike more formal; while the Mohammedan rendering of leafage is so remotely related to nature that one scarcely resents the deliberate way in which the principle of growth is disregarded.

Yet it is hard to reconcile one's self to the absence of something like growth, even in the most arbitrary forms of ornament. It is interesting always to be reminded of nature; and I think that the ornamentist who has any love for nature, or any knowledge of it, will, as a matter of course, make his ornament grow. Moreover, he will make it conform at least so far with nature that at all events it shall never present the appearance of an agglomeration of ill-assorted natural details. Certain features in his design may, for example, recall familiar leaves, and flowers, and fruits, and so on. But he will not associate single flowers with fruits that grow in clusters, catkin blossoms with seeds in pods, woody leaves with tender twining stalks, nor tendrils with the growth of a forest tree. According to his acquaintance with nature, he will abstain, instinctively, from all such incongruities. I know that the artists of the later Renaissance made all manner of flowers and fruits grow inconsequently from a single stalk; but I am not prepared to accept the artists of the later Renaissance (for all the masterly ability of some of them) as safe guides in the matter of taste; nor, indeed. to accept any precedent that cannot justify its claims to our respect. Let every precedent be stripped of its prestige, and as strictly looked over as the newest of recruits, and let the rickety ones be dismissed with thanks. The accepted precedents are not all sound.

I should say, for instance, that though there is much to be learnt from the Gothic rendering of flower forms and foliage, it by no means solves for us the whole problem of conventional treatment. The vine was treated in the middle ages with a simplicity and breadth worthy of all respect, but without great appreciation of the characteristic vine forms. The inevitable regularity of the "ecclesiastical" grape clusters becomes eventually wearisome, and the accompanying tendrils have seldom any very close relation to the forms of nature, which, nevertheless, are admirably ornamental in their growth.

The Tudor rendering of the rose is in many respects masterly. I doubt if it can well be improved upon. But the seed vessels of the plant have been turned to

Fig. 23.

surprisingly little account in design; and so have the thorns, again, though they invite an ornamental treatment, which, so far as I know, has not been attempted.

The Gothic lily is represented not unfrequently with five petals, so little is it studied from nature, and there is seldom much recognition in mediæval work of that peculiar wiry twist of the leaf which is so characteristic of the plant (Fig. 23). The symbolic passion flower, again, is always rather tame; its tendrils are only remotely like nature; and the broad, distinctive stipules of the leaves, decorative though they be, are turned to no account.

*A propos* of the passion flower, it should be observed that obviously elegant and graceful forms of growth, such as the passion flower, the convolvulus, the fuchsia, the birch tree, and so on, do not, as a matter of course, lend themselves most kindly to ornamental treatment. Sometimes it seems as though the contrary were the case, just as it is not exactly in romantic or what is called picturesque scenery that the landscape painter finds the best subjects for pictures.

The Japanese treatment of plant form is always more characteristic. The artist evidently goes straight to nature for his inspiration, and though he indulges


Fig. 24.

sometimes in angular and ugly forms, there is always a decorative as well as a natural quality in his design. He knows, indeed, how in season to compel all natural forms whatsoever to submit to decorative needs. He can be on occasion most uncompromising in the way he will sacrifice nature to his purpose, but it is obvious always that it is not from ignorance or incapacity that he makes the sacrifice. The conventionality of his treatment is the outcome and the evidence of the supremacy of decorative instinct in him.

Though nothing can well be more ingenious than the way in which a Japanese will adapt a natural form to any ornamental purpose, the forms he indulges in are, as I said, by times more characteristic than beautiful. The reverse is the case with certain 16th century Italian adaptations of floral form. You see, for example, the ornamental rendering of familiar flowers, in which the original is endued with a grace of line, and a general suavity of form, not characteristic of, and probably not to be found in, the natural growth of the plants themselves. This is all in the right direction—in the direction of ornament, that is to say. But still, if the forms are very like nature, one somehow misses the natural characteristics of the plants, and the effect is not *quite* satisfactory. The Italian treatment of the lily (Fig. 24) is more graceful than literally natural.

The question arises then, as to how far one is bound to adhere to the lines which a plant naturally takes. Obviously, the simplest plan is to select such forms as are at once most characteristic and most ornamental. They are often identically the same. Where they are not, then one would say, choose at least those characteristic forms which do lend themselves to ornamental treatment. Were we to select only forms readily amenable to ornament, all difficulty would be anticipated. But it must be remembered that many of these accommodating forms have been, as we may say, appropriated, and have become so hackneyed as to have lost no little of their charm. How can we treat the trefoil, the lily, or the rose, without recalling the stock patterns of the church furnisher?

Certain "ecclesiastical" forms, as they are called, have become (not, perhaps, without reason in the first instance) so terribly familiar, that it is almost impossible to shake off the tyranny of the traditional rendering. Even then there is usually, as I have said, something left for us in the way of development. It is seldom that a subject has been sucked quite dry, whatever the traditional drain upon it. For example, we have grown rather sick of the sunflower, it has been used and abused so unmercifully. But little notice has been taken in ornament of the very sportive way in which it throws out occasional leaves from its involucre (or what looks like the calyx of the flower) in a manner admirably corrective, in its very friskiness, of the rather formal growth of the flower. Nor has due advantage been taken of the variety afforded by the back view of the flowerhead. And so with many another well worn type. The travesty of certain forms, if not the familiarity with them, has led to a certain impatient contempt of anything of the kind. One is fain, therefore, to seek some new thing, and is driven ever farther and farther afield from the obviously available shapes.

Moreover, there occur cases in which, for symbolic or other reasons, quite apart from ornamental considerations, but none the less imperative, some particular, and perhaps particularly awkward, plant is given us, to do the best we can with it. In such a case one may possibly correct the contrariness of its growth by intertwining with it some other plant which is, so to speak, complementary to it, and by means of which one may secure that grace, balance, breadth, or other ornamental quality without which it would be hopeless (Fig. 25).

The supplementary forms introduced need not of necessity be floral. The convenience of bird forms, butterflies, etc., is obvious—so obvious as to have been too readily accepted as a means to a not very ambitious end. It is preferable at least that any creatures introduced should have some *raison d'etre* beyond that of just filling a gap. Nature herself often gives a hint to the designer. Notice for yourself the flowers which attract the bees, and do not make them dive for honey where there is none to get. And so with butterflies, what flowers they affect. I was noticing, this autumn, how the common broom, whose foliage is so diminutive as to go for little, was dotted over, after a shower of rain, with dainty little snails, whose delicately marked shells formed quite a feature in the pattern of the shrub. And, since it is ornament that we are discussing, let me digress for a moment to the consideration of shells—how exquisitely they are ornamented, and how little has been made of shell forms generally in ornament. The mine of suggestion in the cockle or scallop shell has been worked out, indeed. But designers have sought no further, perhaps because of the supposed obligation of working in a given "style." You have but to use the accepted shape, and your work is accepted, for Renaissance let us say, but the introduction of a snail shell, a mussel, a limpet, or a barnacle, would be questioned, and possibly resented. It is true that the chosen shell was probably the one most useful in ornament, but its symbolism has ceased to have much meaning for us, and *toujours* cockle shell begins to get stale at last.

To return to natural form not in itself readily amenable to ornament, it is a simple expedient to associate with it objects more purely ornamental—scrolls, ribbons, labels, and the like—as the Italians and their French followers very generally did, and so make sure of the lines you want in your design. But this is to evade the difficulty rather than to master it.

The question is how, without eliminating the natural element, to make natural forms subservient to decoration. The boundary line between the natural and the ornamental is not by any means a hard and fast one. The adherents of either side are continually encroaching on the domain of the other. The one party claims more for nature, the other more for art, that is all. The one would shift the line a little further in this direction, the other in that. It is only a question of rectification of frontier; but it is none the easier settled for that.

With regard to the actual lines of design when the choice is between the natural and the ornamental, the better plan appears to be rather to persuade the natural and characteristic growth into lines more in harmony with ornamental purposes, than to take merely arbitrary or accepted lines, and proceed to clothe them

Fig. 25.

with leaves and flowers from nature. The Greeks did, I am afraid, sometimes in the days of their decadence adopt the latter device, but that does not justify it or make it right, and they did not more than half succeed. It is only when the leaves are equally remote from nature with the lines connecting them that their arbitrary connection ceases to be unsatisfactory. The mere scroll with its leaves alternately on either side (or leaves and flowers, or leaves and berries) is objectionable just in proportion to the naturalistic rendering of the leaf, flower, berry, or whatever it may be.

The acanthus scroll, whether Greek, Roman, or Renaissance, is clothed with foliage very happily reduced to a condition as ornamental as the lines on which it grows. And if you adopt a spiral, wave, or other set line, you're bound in consistency to make its foliation proportionately removed from nature. In Oriental border patterns the paramount importance of ornamental consideration is everywhere observed. Lines and leaves are equally remote from actual natural growth. But what is to be done when something like natural representation is sought, and yet the lines of growth peculiar to the chosen plant are not precisely in the direction of ornament?

There is a certain beauty in the stiff growth of the already mentioned lily, and it may sometimes be well to retain this characteristic. But it is stiff, and the ornamentist may fairly seek his lines of growth more graceful. Still he should scarcely make it branch like a shrub or twine like a creeper. Some familiarity with the natural growth, and sufficient practice in ornamental design, will, together, probably suffice to suggest to him lines, graceful enough, which yet do not contradict the natural growth, and which, perhaps, even recall it, although the possibility will depend, to some extent, upon the proportion of the space he has to occupy.

So, in rendering the peculiar twist of the leaves (to which I have once before referred), it is not beyond the resources of the ornamentist to suggest this peculiar, but sometimes angular and even ugly, growth in a manner more ornamental. This indeed is accomplished in some painted presses in the sacristy of S. Pietro at Perugia (*not* Fig. 24), where the lily takes preternaturally graceful and flowing lines, and is, in fact, almost pattern-like in its growth, while it nevertheless does distinctly recall the growth of the plant, and was obviously studied from it. It is evident, in short, that the artist looked at the flowers for himself, and conventionalized them according to his needs.

This is the natural evolution of ornament, as distinct from the distortion of nature, which is mistaken for ornamental treatment.

While insisting upon the necessity of some modification of natural forms, then, I would insist no less that the modification should be our own. The "traditional" is something to be squeezed for our nourishment, not dried for our imitation. We are too ready to adopt traditional forms, as though all necessary modification had been done for us beforehand. But no good work was ever done in that way. The modification was always in reference to the thing to be done, and there was a much more constant reference to nature than we are accustomed to suppose. In our modern affectations we are so much more Gothic than the Goth, so much more classic than ever the Greek was. I have seen Greek foliage (for example in the Louvre) which, if one had done it nowadays for Greek, would certainly have been accused by the purist of betraying Gothic, or even Japanese, influence. There is a variety even in the antique very much at variance with the stereotyped character which passes muster with us for classic.

The place of *accident* in reference to design appears at first sight easy enough to define. Is not accident, as its name implies, the very antithesis of design? And yet it is to some extent owing to the elimination of what is accidental in nature, that conventional ornament, like academic figure work, is so tame and insipid. The orthodox is undeniably dreary.

But this dreariness is not the unavoidable result of due selection on the part of the designer, but of his adopting a ready made selection, the very meaning of which has no real significance to him individually. Design implies invention; and accident is at all events prolific of suggestion to the inventor.

The designer, no less than the most aggressive realist, should, in his own way, take every possible advantage of the accidental in nature, of every accident which is suggestive to him of characteristic, beautiful, or useful design; not, of course, of the merely ugly or repulsive deformity which others have, for obvious reasons, weeded out of their borders. For ornament is the product of a garden, not of a wilderness. If, on the one hand, it may be found too formal in character, on the other there is a danger that it may be allowed to run too wild. The fear of over culture is not an excuse for allowing it to run to seed. Art depends on cultivation, and ornament is just nature trained in the way it should go.

In conventionalizing floral forms, there is some fear of a formality similar to that affected by the typical gardener, whose idea is not in the direction either of art or beauty. The types of the florist are excellent examples of what *not* to do in the way of modifying nature. Look at the dahlia as the gardeners have made it. It is beautiful only in respect to color; but if you observe the bud in its various stages, to which attention has not been directed, you will find shapes much more natural, much more beautiful, and quite peculiarly adapted to oanament. The elimination of whatever is wayward, characteristic, and uncommon, is *not* advisable on any account whatever. To reduce a flower to the likeness of a rosette is not necessarily to make it more ornamental; and any accident which shows a return to nature is welcome as a relief from such—shall I say academic?—evenness of form. Nature is fruitful of such accidents. Did you never notice how the poppies in the corn hardly ever get over the crick in the neck, which comes of their hanging their heads so long in the heavy bud state? There is always a tell-tale nick in the stalk of the full blown flower, still more plainly to be seen when the petals have dropped off, and the seed vessel is left naked. It does not stand up straight and stiff, like a barrel on a pole.

The geometric order of the floral parts does not in nature result in the mechanical effect so often seen in our attempts at ornament. If the leaves spring at somewhat regular intervals—they do spring. Notice the way many leaf stalks thicken at the point of junction with the stem, as in the sycamore; or how the stalk itself is often pulled out of the straight, as it were, by the leaves, as in the lime; how the stipules enrich the meager joint, as in the thorn; or wrap it round and mask it, as in the fennel and all manner of grasses. The horticultural ideal is the evenest of all possible flower heads, a spike of blossoms as trim as a clipped yew tree or a French poodle. But nature indulges very rarely in that cheap kind of symmetry, and when the spike itself is very regularly shaped, the actual blossoms have a way of shooting out more or less casually and accidentally. This is very noticeable in the salvias, for all the gardener's pains with them. In the woods you see everywhere what variations nature plays upon a symmetrical plan. This is all to show how order is not in any way dependent upon evenness—not to show that nature does the ornamentist's work for him.

As a protest against unintelligent artificiality one may welcome even rusticity; but one wearies of mere reactionary realism. The needful thing is to go to nature, and to choose for yourself; but the choosing is as essential as the going to nature, and the choosing not only of natural types, but of the accompanying accidents, in so far that they may be serviceable in ornament. Who does that may stray from nature as far as he pleases; his work will not be vapid or uninteresting to any one at all interested in ornament.

Let me illustrate more fully what I mean by accidents available in ornament. Did you ever notice the way an apple tree blossoms? Not only are the buds arranged upon a formal plan, but it happens that the topmost flower blossoms first, so that, as a very frequent result, we see a single open flower nestling among pink buds. Nothing could well be more ornamental than that pale, central, five-petaled flower, encircled by a series of five pink balls. And then, if you examine those compact little balls, how admirably the folding of the petals is marked! You could not invent lines more absolutely graceful. In the similar, but larger, bud of the common peony one seems, by the way, to see the origin of the Norman "ball flower." To treat a flower adequately one has to watch its growth, and seize the moment favorable to ornament. It is not enough even to observe a plant throughout

Fig. 26.

the season. In many cases it is seen to advantage only in certain years, when the season chances to favor a development more suggestive of ornament than usual.

In a wet season, for example, when things grow quickly, the ordinarily confused effect of many plants is done away with. The stalks being longer, and the features further apart, the growth explains itself. It has, in fact, been simplified by natural causes, and adaptation to ornamental purpose is often little more than simplification.

You may have noticed, now and again, where a young oak tree has been cut down close to the root, and it has shot out a ring of young shoots all round it, so that it had all the appearance of an exceptionally perfect wreath of oak leaves on the ground. A few days later, and that effect would be lost, and the designer of an oak wreath would find no living, growing model to work from.

Again, what a difference it makes, and it depends very much upon the season, whether the sepals of the flower remain on the ripened fruit (witness the medlar or the hip of the rose), or whether the stipules at the base of the leaf stalk, and the bracts at the axels of the flower stalks, adhere or wither and fall off, which also is very much a question of the season. Then, certain fruit trees in certain years begin to bloom again while the ripe fruit is yet on the tree.

The bursting of the full pomegranate fruit has been made use of in ornament, for reasons as much of symbolism as anything else, but what a numberless variety there is of seed vessels whose opening is suggestive of ornament! The spindle berry occurs at once, the seed vessel of the garden plant called honesty, the pods of the iris, the pea, and all kinds of vetches. Even the dried husks, out of which flowers and seeds alike have fallen, are often delightfully ornamental.

It is noteworthy, again, how, for example, in the oak, the acorns fall, and the empty cup lends itself to fresh forms of ornament, how there is usually at the end of the fruit stalk a withered little button or two, which never arrive at due development, and how the gall fly comes to the help of the artist, and furnishes him with what is as good as a second fruit form, which grows, too, in places where fruits would never be. The feathery burr that besets the rose and other plants is equally suggestive.

It is necessary, of course, to know the system upon which each particular plant grows, but nature is not always quite so careful to emphasize the fact as is the botanist. I am not scientific enough to say how far natural forms are actually modified by nature for the occasion, but I know that, under certain conditions, not uncommon, plants seem to grow differently from what botanically we have been taught to expect. Thus, where there is no room for leaves to grow alternately or spirally they will spring out all from one side. I once made a note of six or seven consecutive leaves of the passion flower, all springing apparently from one side of the stem. Had I ever taken that liberty in ornament, I should have been told that it was pure convention.

In the accidental twist and turn of the leaves of a plant there is always something to be learnt, and, somehow, the same accidents happen to the same plants, and not indiscriminately to all. There is doubtless always good structural reason for the peculiarity, if we looked deep enough for it.

No feature of flower growth has been more badly treated than the tendril. Artists have thought themselves free to add a tendril to any plant whatsoever, and wheresoever they wanted it. And what tendrils! The poets of another generation were wont to compare the tresses of their lady loves to the tendrils of the vine, and there is sometimes a corkscrewy look about the two which might justify the comparison. But what a lively corkscrew is the tendril! How gayly it starts on a second lease of life, and how varied it is! How ornamentally it twists and twirls about, how it gropes for something to catch hold of, and how vigorously the full grown tendril contrasts with the tender, silky growth of the young shoots! And then how different is the branched tendril of the vine from that of the common pea, how different both from the simple bryony tendril!

The twining character of the bindweed, hop, and such like plants, has suggested, to artists who look without their eyes that they must have tendrils to hold them up, and with tendrils accordingly they provide them, neglecting the essentially ornamental character of the twining stem. So, too, the suckers by which the ivy and the Virginia creeper attach themselves have been overlooked, and impossible tendrils invented. Equally ignored in ornament are plants such as the clematis and nasturtium, attaching themselves by their leaf stalks, which fasten in the most ornamental fashion on whatever they can lay hold upon.

Comparatively slight decorative use has been made of the stipules of leaf stalks, which, for example, in the pea, the passion flower, and the sow thistle, assume distinctly ornamental proportions. But even in the less marked form in which they appear—say the medlar, the hop, the common nettle, etc.—they are useful in ornament, as might also be the *scars* left by the fallen leaves, with which at times the stems of certain trees, such as the horse chestnut, are naturally decorated.

It is strange that the leaf bud has not received more general attention in ornament. Occurring as it may at the axel of any leaf, it affords, together with the incipient shoot, a most convenient means of filling the empty angle between the leaf stalk and the stem. The young shoot also gives an opportunity of contrasting with the larger forms of the design details on a smaller scale—an opportunity invaluable in design. You see this very markedly in the chrysanthemum and in some of the solanums.

By the way, not nearly enough notice has been taken of the manner in which the color of the flower stalks is very often more in harmony with them than with the leaves, as in the bigonia, salvia, sow thistle, and many others. We are too much disposed to take it for granted that the flowers are red, blue, white, yellow, purple, and leaves and so on green. But the leaf stalk is sometimes bright crimson, as in the little wild geranium and the sycamore, or brilliant yellow, as in the case of some poplar leaves. Leaves themselves are often anything but green. I don't mean that they are merely grayish, as in the corn flower or olive, which they seldom are, or that they change color as they fade in autumn, but that they are rose or madder colored, as in the late shoots of the oak, briar, hornbeam, etc. And then, again, the variety there is in the backs of leaves!—purple, as in the wild lettuce; rich red brown, as in some magnolias and rhododendrons; silver gray or white, as in certain alders, poplars, and willows, and some garden plants.

The Japanese have made the frankest possible use of this feature. They will deliberately make the turnover of a black leaf white, or sketch its reverse only in outline, always with admirable decorative instinct. But it is impossible to point out at further length all the various ways in which nature throws out hints to the ornamentist. They are as multiform as nature herself.

I have said that to conventionalize is often but to simplify. Thus, the character of early English (thirteenth century) foliage is so simply early English, that it is open to dispute which trefoil form suggested it. None of them, very likely. It grew most probably out of Byzantine forms, themselves derived from the classic acanthus, and it was only when they had arrived, through symbolism, at something suggestive of clover, or wood sorrel, or hypatica, that the carvers took to making the symbol yet more like a natural growth.

But in very many instances, undoubtedly, the simple necessity of simplifying the natural form was the reason for its conventional treatment. The omission of the superfluous is, obviously, so far right. How far it may be desirable to add to a natural form characteristics which do not belong to it is more open to question. For my part, I am not disposed to quarrel with the invention of the Tudor rose, nor with the *flamboyant* character of later Gothic foliage, though I am bound to admit that the bedecoration of natural forms (as we see, for example, in some perpendicular carving) is dangerous, if we wish at all to preserve the natural character of its original. If our purpose is mere ornament, then we are comparatively free. But it is worth bearing in mind that it is always better to suggest growth than frilling in any addenda we may make.

Whatever the liberty to be claimed in this respect, it is distinctly a mistake in taste to give, as the late Gothic carvers did, to leaves in wood or stone the bulbous look of beaten metal work.

There would seem to be in nature some sort of precedent even for the artificial befrilling of floral forms. There is a particular kind of crinkled cabbage, which looks as if the milliner had taken it in hand. Certain

ferns grow with every appearance of artificiality. And I came not long ago upon a little wild flower, unknown to me by name, looking for all the world as if it must have been designed somewhere about A. D. 1500.

There are various ways, then, of modifying natural forms. Apart from the consideration of the circumstances of the case in point, we have for our guidance or for our warning the ways in which natural forms have till now been manipulated by the ornamentist. There is the graceful Greek way and the energetic Japanese, the rigid Gothic and the more strict Egyptian manner, the fanciful Chinese and the sauve Persian, and again the manners of the Renaissance from the fifteenth century to the eighteenth.

The most naturalistic type is afforded by the Japanese. They start so frankly from nature, and yet they are so careful of the conditions of decoration, that one scarce knows which is uppermost in their minds, nature or ornament. I fancy they went pretty simply to work, and copied nature as nearly as their tools and the general conditions allowed, conventionalizing, so to speak, as the circumstances suggested or the tools demanded, but they never lost sight of the fact that they were decorating something—that would have been fatal. I do not mean to say that Japanese ornament is in every way perfect. It lacks many qualities which are indispensable to us, but in the mere treatment of natural form as naturally as possible, and yet ornamentally, there is probably more to be learnt from Japan than from any other source. The stained glass window pane (Fig. 26) shows both Japanese and Gothic influence.

In the more essentially ornamental treatment of forms borrowed from nature the Greeks excelled, as they did in most else. The Corinthian capital, or the acanthus scroll, as they carved it, is perfect. Unfortunately, we have been too content to copy their forms, instead of trying to conventionalize in their manner.

In Eastern art, Indian, Persian, and Chinese, there is again a great deal to be learnt, if only we would borrow their art, and not simply the Oriental forms. Once more, our art ought to be ours.

It is easy for any one who is susceptible to the beauty and charm of nature (and the artist, of all men, must be supposed to have that susceptibility) to understand how many persons feel a kind of resentment at the very idea of interference with nature. To disturb it is to deform it, no doubt, but in the interest of cultivation it has to be done. Brier, and bracken, and golden gorse, must give place to apple orchards, rose gardens, and fields of corn. They, too, are beautiful, not the less so that they owe something to the hand of man. It is, after all, a false and rather a cowardly sentiment which makes us afraid of disturbing what is beautiful, even for the sake of a beauty better worth having.

Those who profess to follow nature seem sometimes rather to be dragging her in the dust. There is a wider view of nature, which includes human nature, and that selective and idealizing instinct which is natural to man. It is a long way from being yet proved that the naturalistic designer is more "true to nature" than another. It is one thing to study nature, and another to pretend that studies are works of art. In no branch of art has it ever been held by the masters (least of all could it be held by the masters of ornament) that nature was enough. Only the green student is overpowered by the model before him. The mature artist shows his mastery by making it subserve his purpose. The beginner may condescend to "crib," the artist conceives. It is the rustic who says: "Lor, how natural!" The connoisseur thinks to himself, "What perfect art!"

I have now come to the end of this short series of lectures. It has been impossible, of course, to give you much more than a glimpse of a subject so wide as that of ornament. I cannot flatter myself that, in four short hours, I have taught any one of you much. But if I have aroused any interest in the subject which so deeply interests me, or given encouragement to any, I shall have done all that I had any hope of doing.

## THE HAVRE MARITIME AND INTERNATIONAL EXHIBITION.

THE Havre Maritime and International Exhibition, organized under the auspices of the Syndicate General of Commerce and Industry, will be opened in a few weeks.

Havre, faithful to her traditions, and inspired by the present tendencies toward colonial expansion, proposes to bring together and exhibit, not only the products of importation, but also those which find a market in countries beyond the sea, in order to facilitate and multiply our commercial and maritime relations.

The latest improvements introduce into the building, armament, and propulsion of ships will be largely represented, as is shown in a brief list given further along.

The exhibition will be *international* for all the industries connected with maritime affairs, fishing, and electricity, and *national* for all the products imported from or exported to the French colonies.

The floating exhibition will comprise almost every type of vessel, from the smallest pleasure yacht up to the man of war. The dryness of the exhibition, which, although of a special nature, is of interest to everybody, will be strongly tempered by the fetes that will be constantly offered to the public. In addition to concerts, day and night, festivities will have place in the harbor, where international regattas will also occur to enliven the scene. All this is now elaborated and prepared for. Nothing has been left unforeseen.

The work itself is being pushed forward with great activity. Not only are the galleries now nearly completed, two months ahead of time, but charitable festivals have already been given in the building designed for the colonial exhibition. The promenade leading from this building to the galleries of the Place du Theatre is finished, and will offer to visitors the curious sight of a continuous gallery 600 yards in length. The platform, which likewise is completed, consists of an enormous framework elaborated with a view of supporting the most closely packed crowds. This promenade, which is external to the galleries, will be the resting place preferred by visitors, who will here enjoy a general view of a maritime haven filled with vessels, great and small, and enlivened by a continuous movement of rowboats.

In order that too long a detour may be avoided, the two sides of the dock will be connected at the center by a foot bridge having a central draw.

The framework of the central building of the Place du Theatre is finished. It is now being decorated, and it is already possible to judge of the architectural effect that the principal facade of the exhibition will exhibit. The decoration, which is Oriental in style, is in perfect harmony with the destination of the work, and does the greatest credit to Mr. Harel, who conceived and is doing it. It is necessary also to congratulate Mr. Pombla, who has carried on the work with much order and punctuality, and who builds boldly and lightly without, however, neglecting strength.

It must not be forgotten, in fact, that on the 26th of last December, the partially inclosed buildings withstood a terrible gale without any injury.

All the results mentioned are due to the skillful and firm direction of Mr. Benard. The organization of the exhibition, which likewise has been confided to him, is proceeding satisfactorily.

The classified applications for space represent at present, under the covered galleries, a surface of more than 160,000 square feet, although the opening will not occur before two months, and although many manufacturers who have decided to take part in the exhibition have not made known how much room they will require.

It would take too long to give a list of all the exhibits. Among the exhibitors who will offer particularly attractive displays, may be cited the following:

The minister of the navy and of the colonies, with the corvette La Favorite, upon which is being organzied a complete exhibition of naval hygiene.

The city of Havre, which will make known the best work of its professional schools, and give a very important grouping of the products of our colonies and of the countries under our protectorship.

The Chamber of Commerce, which will exhibit its powerful and ingenious salvage apparatus, its collections of products, its models of apparatus for improving harbors, and a large plan of the city and its establishments, a part of the latter in relief.

The government engineers, who have had very faithful models made of hydraulic apparatus of the most recent type for maneuvering bridges and canal locks.

The Bureau Veritas, which will exhibit a very large collection of ship models.

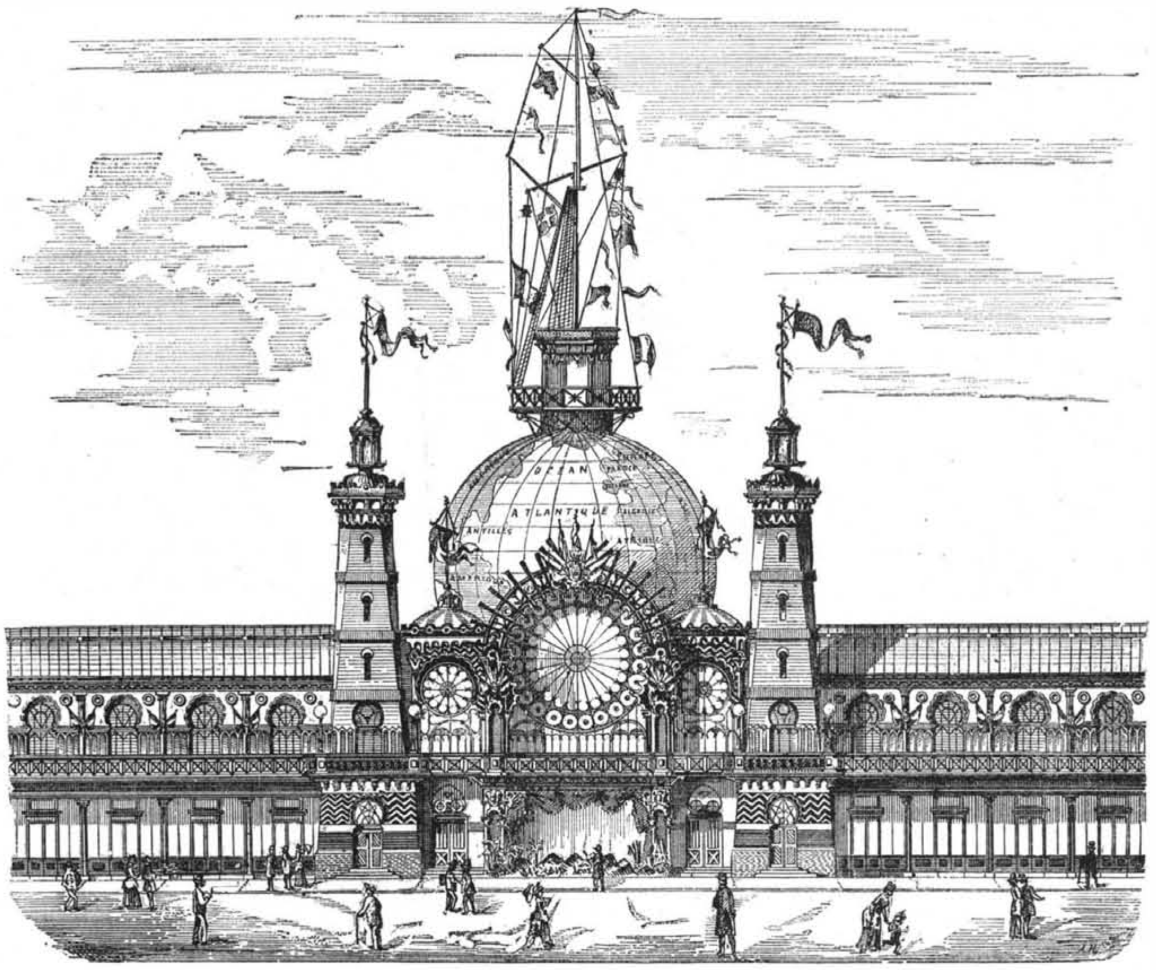



FIG. 1.—HAVRE EXHIBITION BUILDING (FRONT).

The Compagnie Generale Transatlantique, which will show the style of cabin used on its new steamers.

The United Shippers, who will show models and sections of the steamers of their fleet.

The Forges et Chantiers de la Mediterranee, who will exhibit a torpedo boat engine, an electric boat, artillery, etc.

The Ateliers et Chantiers de la Loire, which will exhibit an advice boat engine, marine boilers, etc.

The other large builders of Havre, who will exhibit windlasses, steering machines, etc.

Then in general the exhibition will include: generators of various systems for workshops; generators and apparatus for commercial and naval ships; boiler accessories, such as grates, injectors, etc.; steam engines and propelling screws; gas engines; steam and other windlasses; steam engine accessories of all kinds; steam and hydraulic cranes; sugar machinery; centrifugal and other pumps; metal working machines; wood working machines of all kinds; machines for grinding dyewoods; stone crushers; sewing machines; linen washing machines; meters and analogous apparatus; heating and ventilating devices; builders' and ships' hardware; metallurgy; cables and wires; building materials, etc.

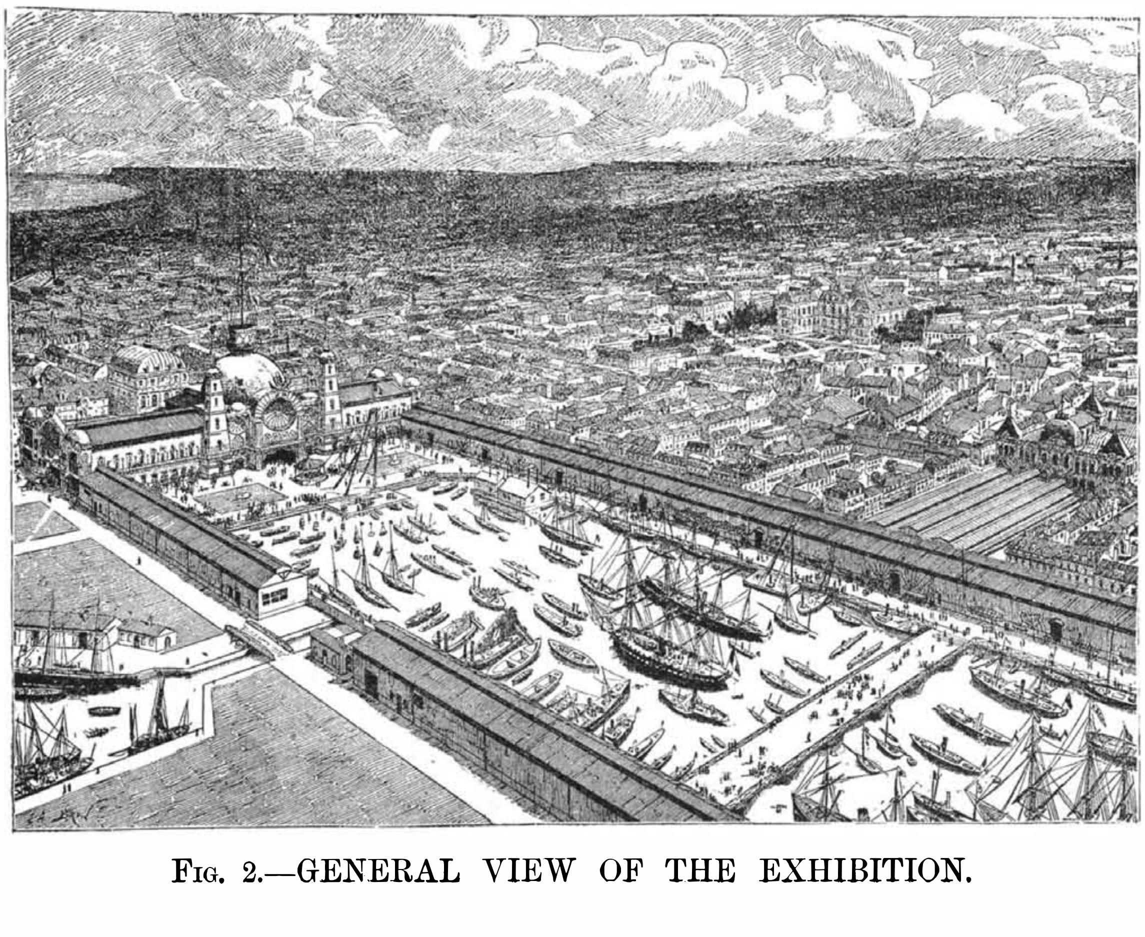


FIG. 2.—GENERAL VIEW OF THE EXHIBITION.

A power of 500 horses will be at the disposal of exhibitors, and this will be furnished by several steam engines, and one gas engine of 30 horse power. The steam will be furnished by a series of large Collet boilers, arranged for marine service.

Electricity will be largely represented. The building, its facade, its garden and its main galleries, will be lighted by electricity for the night fetes.

The new works of the port, which are nearly finished, will likewise offer considerable attraction, and, along with the exhibition itself, will mark the immense progress made by our chief port on the Channel.—*Le Genie Civil.*

## THE TELEPHONE AND PHOTOPHONE.*

By Professor A. Graham Bell.

It was my intention to give a description of the elements involved in the transmission of speech to a distance, but after a look at the munificent equipment of your physical laboratory, it may not be well to linger over over some of the more elementary propositions with which you are, no doubt, already familiar.

In attacking any problem it is best to have it clearly formulated. What is our problem, and what is the process by which we are to solve it?

First—What is speech? Speech is like sound itself, a mere sensation in the breath. Outside of ourselves there is no sound. Speech requires a brain to formulate, and a brain to receive; it is, therefore, a mere sensation in the brain, caused by a movement of air on parts of the ear. The movement of the air is thus the object to be reproduced, and causes sound or speech. How may this then be brought about to produce an air movement to effect the sensation of sound upon the brain? What is this movement of the air? Perhaps one of the easiest of general considerations is to compare it with water. If we throw a stone into a body of water, waves in the form of circular rings go forth. Thus, if we disturb air, circular rings of waves are propagated, but with this difference—the rings are circular in all directions, or spherical like a soap bubble, rapidly expanding, but with a velocity which can be measured, but not appreciated. If we observe the flash of a cannon, and note the time required for the sound to reach the ear, we can, knowing the distance, calculate the velocity of the sound.

When a succession of air impulses is caused to strike the ear, a musical sound is produced, if the impulses are more frequent than thirty-two per second, just as in a dark room the light of a cigar can easily be distinguished if it have a slow movement, whereas if it be moved rapidly, owing to the persistence of vision, a continuous line will be produced. Thirty-two times per second being then the least number of vibrations which constitute a musical note, the tone increases from this as a lower limit up to about four thousand vibrations, after which it ceases to be pleasurable. This existence of sound waves is not mere theory, but can be easily demonstrated experimentally. That air can be moved in waves no one can well doubt, especially after observing the oily effect when light passes through heated air, such an effect as we have often observed when watching a heated stove, or a chimney outlined against the sky, pouring out oftentimes no smoke, but this oily substance of the air, or, perhaps, we have noticed it as the heat rolls up from a heated street on a sultry day. But by sound waves do not gather the idea that the waves mean an actual transference of air particles, nor by waves the idea that they, as waves, strike our ears. They are more correctly sound spheres. What is the action then? Let us take an example of a large wheat field. As the breezes strike it, we see the waves most beautifully roll over it, precisely as the billows on a larger sea. But no grain of wheat is transferred from one part of the field to another. The action of the grain waves is as the action of the sound waves in air. The air particles do not move, *i. e.*, are not transferred, but simply vibrate back and forth in an extremely minute distance.

What causes sound? What is the nature of that vibration which is so extremely small? Wherein does sound vibration differ in properties from other vibrations? These are the propositions we have to deal with in the transmission of speech. Sound being a vibration, in order that we may communicate sound to a person, we must vibrate his ear. In order that speech may be made and apprehended, a marvelous process is going on. A mind conceives the thought, the nerves call upon the vocal muscles; the muscles pronounce with audible speech, that is, certain air vibrations are produced. These vibrations fly to a hearer, act upon the muscles of the ear, the nerves carry these muscular tremors to the brain. Thus is the thought in my mind transferred to your mind. Why is the thought in my mind transferred to your mind? Why is it that certain sounds produce certain ideas in the brain? What is it that causes a difference in the quality of the sounds? This is then the problem.

The ear consists of a highly drawn membrane free to pulsate under the sound vibrations. How then can this membrane distinguish the ever varying differences in sound?

Each vocal sound has three different characteristics—pitch, loudness, character, or as the French term it, *timbre*. The *pitch* depends upon the frequency of vibration, a note high in pitch being one in which the number of sound vibrations are very great. The *loudness* of a sound depends upon the amplitude of the vibrations. Recurring again to our wave theory, if we on our pond of water have the waves succeeding each other with great rapidity, we have the effect corresponding to pitch, but if the waves are high we have the effect of loudness; although both the rapidity and the height, and therefore the pitch and the loudness, may be independent of each other. Upon what does the *character* or *timbre* of the sound depend? We have both the rapidity and amplitude of the sound wave, now what other effect can take place of this nature in order to effect what we term timbre? May not the wave itself be changed between intermediate points, or smaller waves be produced on the waves?

For illustration take the case of two boys running a race between two points. They as it were make an oscillation. The more times they run back and forth, the more oscillations. The number of oscillations corresponds to the pitch. Then will also the character be indicated by the mode in which the combatants run. Thus one may run with a sideways swaying motion, another forges straight ahead, while perhaps a third falls alternately behind, then spurts ahead. The same thing may be shown more graphically by having a board, representing say the race way, held by two persons. I hold at one end, in my hand a piece of chalk. Those holding the board walk along a short distance with it, and as they do so I move my hand in various manners, but always up or down, when on the board will appear more or less regularly shaped wavy curves. The character or timbre of these curves will be indicated when these waves have on them, or rather as part of them, a smaller wave curve.

In Boston some years since I was led to make a study of the anatomy of the human ear, and wished to discover just how sound affected it. So under an eminent anatomist of that city I was furnished with that portion of a dead man's skull having an ear and all the adjacent parts. The bone work was then so sectioned that it could be readily adapted to a position on my apparatus conveniently arranged. To the *hammer* of the ear a very light piece of hay was attached, this projected outward and was arranged to just touch a plate of smoked glass. The glass plate was capable of having a lengthwise movement, by being placed upon slideways. When this ear was spoken into, the piece of hay attached to the hammer of the ear was caused to vibrate to and fro. The smoked glass plate was then drawn along. It was then found a continuous wavy line had been formed on the glass. A number of experiments were conducted, but the most interesting are those showing the waves corresponding to the vowel sounds.

Having thus the speech portrayed graphically in the form of curves, and thus knowing that for each wave on the diagram there had been a corresponding vibration of the hammer and tympanum of the ear, the question then presenting itself was, In an artificial ear how can this vibration be produced, and when produced how can it be transmitted to a distance? This was accomplished by the telephone. It is unnecessary to go into an elaborate description of telephonic apparatus. New forms and improvements have so rapidly multiplied that one can scarcely acquaint himself with them. With many inventions their first forms were complexity itself, then later followed simplicity and refinement of construction. But with the telephone it appears to be different, first simplicity then later complexity. The first form was almost the simplest, because it was the carrying out of a single idea, and that one of great simplicity.

Faraday was the first to point out that a current of electricity could be developed by the motion of a piece of iron in front of an electro-magnet. This idea, simple as it is, is nothing more than the embodiment of the telephone. The piece of movable iron in the instance of the telephone is a thin iron disk. We cause this disk to move or vibrate under the influence of sound by speaking near it. These vibrations of the iron disk cause corresponding electrical movements in the coil of wire surrounding the magnet. These electrical pulsations can then be carried off to a distant receiving station. The currents of electricity generated by the iron disk are proportioned exactly to the movement of the iron plate. The disk moves as we have seen, precisely in the same manner as the tympanum of the human ear, consequently the pitch, tone, and *timbre* are taken up by the telephone and converted into electrical currents. The wave lines which we had produced by our experiments on the human ear were seen to be continuous curves of an undulatory character. The electric current thus taking up these sounds must, therefore, have a similar nature, and therefore the name, *undulatory current*, I have applied to it.

This current, as it proceeds from a distant station, traveling along a shorter or longer distance of wire, arranged similarly to a telegraph wire, is received into a receiving telephone, termed the receiver, one perhaps in all respects similar to the telephone which forwarded the words. The undulatory current passes into the instrument through the coil of wire surrounding the magnet, and then out to its return or ground connection. But during the passage of the undulating current it has produced corresponding varying effects upon the magnetism of the magnet. The diaphragm is thus correspondingly attracted and repelled by the magnet, or controlled by the current, moulded as it were, and the same sound waves are reproduced as were spoken at the sending station.

The telephone, as an instrument, is not one of great delicateness. The wonder is that we can hear speech at all. Our ear, which interprets the sound, is the organ of marvelous delicacy. In fact, the operation of the telephone is so simple, that some of even the most crude apparatus serves to transmit distinguishable speech. A telegraph instrument may be made to talk, or a hammer head. In the Hughes transmitter, simply two nails answered the purpose.

Telephones for commercial use are required to be more powerful, and to effect this compound magnets are often employed. Although the hand telephone is not the most powerful, yet its greater convenience has caused it to survive.

Telephonic receivers remain much the same as when introduced, but numerous changes have been made in the transmitters. The one now in most general use is the Blake transmitter, and instruments of its class are known as carbon transmitters. A number of forms have been invented by Blake, Edison, Berliner, and others. In these forms of carbon transmitters a current of electricity from a battery is kept flowing through a carbon button attached to the diaphragm. As the diaphragm, actuated by the voice, is vibrated to and fro, it causes a varying amount of compression to take place in the carbon. Carbon has the peculiar property of offering a greater resistance to the passage of the electric current when submitted to pressure. Thus when the carbon telephone is spoken into, the voice, as it were, simply cuts off more or less electricity. This undulating current, as in the previous case, passing to the receiver, it produces sound in the same manner.

In the case of carbon, we have a variable electric resistance produced by pressure, but are there no other means by which this variation of electric resistance may be produced than by pressure? It has been found that selenium has its resistance altered by the presence of light. If then we can vary the intensity of light which is acting upon selenium, to correspond to our wave vibrations of sound, we can, therefore, accomplish the wonderful result of transmitting speech by light instead of electricity. The chief difficulty in the use of selenium has been found to be its enormous electrical resistance, which is something like 14,000 megohms, or the resistance of a telegraph wire from the earth to the moon. The discovery of this wonderful property of light on selenium is due to Siemens, who, in some cabling experiments, found that the selenium, which he was using on account of its high resistance, varied greatly in its electric resistance during the day time and at night. Quite a number of experiments had been conducted on this strange material by investigators.

It then suggested itself to my mind that this substance might be made a valuable aid in telephoning. An insuperable difficulty seemed apparently to lie in the way—its enormous resistance—and how could it be reduced? Siemens partially effected it by arranging the selenium in a spiral of platinum wire. We tried many experiments with this spiral, but were obliged to discard it; then was tried the plan of placing the selenium in a sort of grating, also as suggested by Siemens, but this also failed to give much more satisfactory results.

At last I was led to devise a method which seemed to more perfectly fill the requirements. The apparatus, which might be described as a selenium rheostat, is constructed of a number of thin disks of brass. These are separated from each other by placing between them sheets of mica of somewhat smaller diameter. The plates are then tightly clamped together, and the interstitial spaces filled with melted selenium. Every other brass plate is connected to form one pole of the apparatus, while the other plates are connected to form the other pole. Thus is it made possible to have a large surface of selenium exposed to the light, and also to have a moderate resistance. The apparatus is also in a convenient form, so that it may be readily used in the focus of a parabolic reflector.

We are, therefore, ready for the *photophone.* If undulating waves of light, corresponding to sound vibrations, are projected into a parabolic reflector in which is placed this selenium cell, the light vibrations will produce variations of resistance in the selenium. Consequently a passing current of electricity will be correspondingly increased or decreased. The result being precisely the same as in the carbon telephone, and it needs only the ordinary telephone to translate into audible sound these currents of electricity.

But how is this variation of light corresponding to the sound vibrations produced? The photophone's transmitter, the means whereby this is accomplished, is simply a diaphragm silvered at its back, and free to vibrate under the action of sound. This is so placed that a ray of light striking it, the light is so concentrated and directed that it can be brought to bear upon the distant photophone receiver—the parabolic reflector. These rather curious results—telegraphing speech by light—we did not come upon at once, but only after long and tedious delays, experimenting with unmanageable selenium.

The first successful experiment was made in Washington. The transmitter with its source of light was placed in a window of my laboratory. I placed myself with the parabolic reflector in one of the uppermost windows of a public school building, 500 yards distant, far enough in order that no speech might be heard without instrumental means. With the telephone attached to the connections on the reflector I waited. I did not have long to wait. Soon my assistant, in my laboratory, spoke into his mirror transmitter. Instantaneously the words were flying over the beams of light. Here is the first message ever transported by this new servant of man: " Mr. Bell, if you hear what I say, come to the window and wave your hat." It is unnecessary to say that I waved with vigor, and with an enthusiasm which comes to a man not often in a lifetime. The feelings which arise within one when, after some vast labor, a great problem is solved, or invention produced, and fraught with so much success, no one can express. They are moments worth a life to live for.

Thus was brought into existence the photophone, and no longer may it be remarked that electricity is the only messenger which will carry our voice to distant hearers.

On experimenting with this new instrument, at one time I happened to take up a piece of hard black rubber which was lying on the laboratory table. Placing it in front of the mirror transmitter in the direct ray of the light between the mirror and the parabolic receiver, I of course thought, as any reasonable being would, that as soon as the waves of light were shut off the sounds in the receiver would cease. Surprisingly to all, such did not seem to be the case. Although the rubber was opaque to light, it was transparent to radiant energy.

Many other substances were experimented with, and yielded curiously varying results, each substance giving forth peculiar musical notes characteristic of itself when thus placed in the intermittent beam of light. In order to hear these sounds it was also, strangely enough, found that the selenium receiver might be dispensed with altogether, the material itself acting as a receiver.

Thus it appears that we have a new property of matter—sonority under intermittent light.

The substances experimented with were of every conceivable kind, gases, solids, and liquids, each having its peculiar characteristics. The substance found to give the most pronounced audible effect was *soot.* In fact its notes could be heard over a good sized room or even a hall.

Taking advantage of this strange property of soot, I have recently devised what we may call *a soot photophone.* The transmitter is the same in principle as that employed for the selenium photophone, *i. e.*, a silvered mirror, but the selenium rheostat and parabolic receiver is replaced by a simple funnel shaped ear piece, the mouth of the funnel being stretched across by very fine wire gauze coated with soot, as well as are the interior sides of the funnel. This apparatus being placed at the ear, the loudness of the sounds produced by the intermittent beam is really uncomfortable.

As it was seen that these causes were not so much due to light as to radiant energy, these new developments in photophonic apparatus might be more properly termed *radiophones*, and the science *radiophony.*

The lecture was illustrated throughout by a large

* Abstract of a lecture lately delivered at Sibley College, Cornell University, by Prof. Bell, inventor of the telephone.—*From the Crank.*

number of admirable drawings thrown on the screen by the large lantern of the physical lecture room. Some of the views of early apparatus were not only interesting, but valuable for their historical value. The speaker throughout carried his audience with him, as his manner was easy and withal intensely interesting. As he described the steps leading up to the invention of the photophone, he held the attention of his hearers transfixed with the same expectancy that the good reader awaits the *denouement* of the plot. On arriving at the lecture room, he may well have expressed surprise, by his introduction: "I scarcely thought in getting in, that I should be able to hear my own lecture;" for never before, indeed, has such a dense mass of humanity collected in that hall. His audience were agreeably surprised to find a man of so modest mien, when he has the distinction of having such exalted honors.

## THE CONDUCTION OF ELECTRICITY BY GASES AT HIGH TEMPERATURES.

M. R. BLONDLOT has presented to the *Academie* a memoir entitled "Researches upon the Transmission of Electricity of Low Tension by Hot Air," of which the following is an abstract: In the year 1853, M. E. Becquerel discovered that a gas at a high temperature became a conductor of electricity, and stated that the phenomenon could be observed even with a single cell. Some doubt has been thrown in later years upon the accuracy of the statement, but it has been fully confirmed by the experiments which are about to be described. The apparatus employed consisted of a sort of double bell jar placed with its mouth downward; between the outer and the inner lining a stream of coal gas was caused to ascend, and being mixed with air in its passage a powerful flame could be produced around the inner lining, which soon raised it to a state of incandescence. Within this heated jar, but entirely free from contact with any part, were placed two platinum disks, about 3 cm. in diameter. These served as electrodes. By means of this arrangement the air could be raised to a very high temperature, while currents of convection were as far as possible avoided.

In accordance with M. Becquerel's announcement, it was found that in this case no current would pass until a red heat had been attained. On the other hand, when a column of air is allowed to rise by convection from a heated body, a current may be obtained with a single element when a thermometer indicates a temperature of only 70° C. The explanation suggested is that the convection current contains many particles which are themselves far hotter than the mean temperature of the air, as shown by the thermometer, and it is these hotter particles which are alone concerned in conducting the current.

In the present apparatus, as soon as a red heat had been attained, an E.M.F. not exceeding one-thousandth of a volt produced a measurable current. It was, however, discovered that this current does not obey the law of Ohm, as on increasing the E.M.F. the current increases more rapidly than the difference of potential. This result, which has been well established, appears to be one of considerable importance as throwing light on the differences between the conduction of electricity in solids, liquids, and gases. It follows that gases, properly speaking, have no specific resistance, as the quantity so measured will depend upon the E.M.F. employed in the experiment. It is probable that the explanation of the phenomenon is to be found in the conduction by convection currents already alluded to. When the air is at the normal temperature, it is known that all bodies are coated with a kind of atmospheric film, which therefore serves as an effective insulator. But when the temperature is sufficiently raised, this film is driven off, and the gaseous molecules then come into sufficiently close contact with the surface of the metal to carry off a charge of electricity.

## ELECTROLYSIS OF COPPER AND ZINC.

By ALEXANDER SHAND.

THE separation of copper from zinc or any other metal is much more easily and quickly conducted by electrolytic deposition than by the ordinary wet process. As the result of some experiments recently conducted, I have found that the electrolytic method is also much more accurate. In order to determine the accuracy of the process, 0·5033 gramme of pure copper and 0·5031 gramme of pure zinc were dissolved in a little dilute sulphuric acid, and the solution made up to 1000·5 grammes with distilled water at 15° C.

Of this solution, 100 grammes, calculated to contain 0·050304 gramme of copper and 0·05028 gramme of zinc, were weighed into a tared platinum basin, and the current from one Bunsen cell passed through the solution, the positive electrode being a platinum disk. The Bunsen cell exposed 140 sq. in. of zinc to dilute sulphuric acid, specific gravity 1·12 at 15° C. The current was allowed to continue all night, the total time being about eighteen hours.

The solution in the basin was now poured into a beaker, and the deposited copper washed three times with distilled water, then three times with alcohol, and finally three times with ether. It was then dried in an air bath at 80° C., allowed to cool in a desiccator, and weighed.

RESULTS OF TWO ESTIMATIONS.

| | | | |
|---|---|---|---|
| 1st | 0·0504 | Theory requires | 0·0503 |
| 2d | 0·0503 | " " | 0·0503 |

A large number of experiments showed that the most accurate results, in zinc estimations, are obtained by the following process. The zinc, being in the form of sulphate, is nearly neutralized, if necessary, with potassic hydrate, free from aluminum; then add ammonium oxalate in excess. Maintain the solution at a temperature of 80° C. or 90° C. by heating with a steam or water bath, and pass the current from two Bunsen cells similar to the one used for the copper estimation. In a few hours the whole of the zinc is deposited as a pale bluish-white coating on the basin; which is washed with water, alcohol, and ether, as in the case of copper, and then dried and weighed.

RESULTS OF TWO ESTIMATIONS.

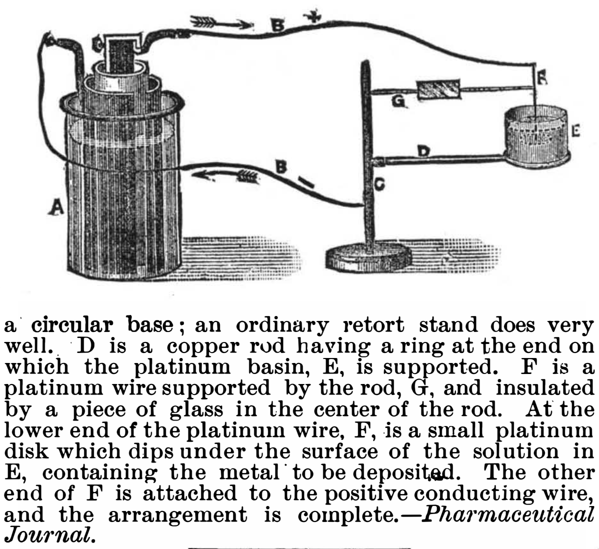
| | |
|---|---|
| 1st | 22·19 per cent. |
| 2d | 22·09 " |

There are a number of practical details and precautions, most of which will occur to any who may be disposed to investigate this process. It is absolutely necessary that the analysis be carried out exactly as described above, and that the platinum basin be chemically clean. If the basin is heated directly with a flame during the process, the zinc is deposited in a black powdery condition, and gives too high results. Should the acid in the battery be too dilute, the zinc comes down in a crystalline state. In this condition it is very difficult to wash without loss, as some of the crystals become detached and are easily washed away. From 0·4 to 0·9 gramme of the metal is the most convenient quantity to work with, as too large a quantity takes much longer to deposit; 1·5 gramme of copper, for instance, takes thirty hours to completely deposit with the current from a single Bunsen cell.

The accompanying wood cut will show a suitable arrangement of the apparatus for conducting the process.

ARRANGEMENT OF APPARATUS FOR ELECTROLYSIS.

A is a Bunsen cell with zinc carbon couple. B B are the conducting wires, and the direction of the current is indicated by the arrows. C is a metallic rod fixed in




a circular base; an ordinary retort stand does very well. D is a copper rod having a ring at the end on which the platinum basin, E, is supported. F is a platinum wire supported by the rod, G, and insulated by a piece of glass in the center of the rod. At the lower end of the platinum wire, F, is a small platinum disk which dips under the surface of the solution in E, containing the metal to be deposited. The other end of F is attached to the positive conducting wire, and the arrangement is complete.—*Pharmaceutical Journal.*

## LIFE ENERGY, OR THE DYNAMICS OF HEALTH AND DISEASE.

By NATHL. ALCOCK.

SINCE it is admitted that matter is indestructible, it is obvious that life can be only the manifestation of that energy which is set free by the reduction of compounds embodying more energy to states of combination which embody less energy.

Life therefore is the result of the continuous interchange of partners between the compound molecules constituting chemical and organic compounds.

"In any transformation which takes place without the application, or the giving out, of work, the heat developed is the equivalent of the excess of the original over the final potential energy due to the chemical affinities involved. The *final state of every combination is that in which the potential energy of chemical affinity is a minimum.*" (Tait.)

If these words formulate the law which governs those combinations of elementary substances known as inorganic compounds, how much more must they refer to the combinations of the same elementary substances which go to form organic compounds?

Life thus becomes an expression for the sum of the difference between the original potential energy of the food and the final potential energy of the excretions. All change in the configuration of matter, whether physical or chemical, must be accompanied by either the evolution of, or the absorption of, energy.

Energy, as far as is known, has but one source, the sun.

Whether that energy act by direct impingement of solar rays producing the ascending scale of effects from genial warmth to fatal sunstroke, or whether it be second hand, from the decomposition of vegetable matter, or third hand, from the decomposition of animal substances which obtained it from vegetable substances, its origin is still the same.

Assuming then the universality of this energy, which shows itself in all the intangible forms of life, and growth, and all organic change, it will be the effort of the writer to adduce evidence to prove that much which is still mysterious in both health and disease is due to its subtle action too.

The vibrations of direct solar energy which fall upon the optic nerve give rise to those molecular disturbances which produce the subjective sensation of light.

Physical change is thus originated by an immaterial agent. Work is done, and cannot continue to be performed without renewal of the material acted on.

But when the vibrations of direct solar energy fall upon the tissues of a growing plant, energy is incorporated into those tissues. This energy so attunes the atomic vibrations in the plant molecules as to bring them into combining harmony with the carbon and hydrogen atoms present in the forms of carbonic acid and water.

The hydrocarbon compound starch is formed, and embodies within itself the energy which made it starch.

Each molecule of starch maintains its individuality as starch only so long as it retains within itself that solar energy under the influence of which it became starch. As soon as part of that energy is lost, the starch is degraded to its original condition of carbonic acid and water. Yet that energy which works such molecular miracles is sought for among the products of decomposition in the form of heat only, and if not recognizable as such is put out of count in the world's work.

While it is thus evident that the vegetable kingdom lives a constructive life, storing up energy from an extra-terrestrial source, it is equally demonstrable that the animal kingdom lives a destructive life, unable to add aught to the sum of energy required for the work of the planet. Consequently an approximate expression for the value of the energy incorporated in the plant may be found in the work done, as a result of its consumption, by the animal.

4,500 grains of plant carbon are daily excreted by every average man in the form of carbonic acid. Carbon and oxygen independently embody a greater sum of original energy than is found in the compound formed by their union. Therefore the result of their combining together must be a loss of energy. The value of this energy is estimated by the heat evolved. The heat recognizable on the combination of 4,500 grains of carbon with the required equivalent of oxygen amounts to 118 units, and represents in foot pounds the raising of 40 tons one foot high.

Such, then, is the enormous supply of solar energy obtained by a man when he compels the elementary atoms of carbon and oxygen to enter into a combination of greater stability and less energy, and to surrender their surplus energy that he may live.

But the converse of this is also true, viz., that when a plant proceeds to utilize this carbonic acid for the reproduction of 4,500 grains of carbon, it can do so only by obtaining from some external source energy equivalent to the raising of 40 tons one foot high and adding this to the rates of vibration already existing in the carbonic acid. Thus the condition of energy of the carbonic acid is altered till finally the oxygen and carbon atoms are compelled to dissociate themselves and to resume their elementary forms of less stability and greater energy. They then become available for plant assimilation, and fix in its tissues the energy which forced them apart.

If, then, the union of oxygen and carbon in the human body sacrifices such energy that man can live thereby, is it not obvious that under whatever circumstances that union takes place, the same energy must appear? If that be so, the question must arise whether in estimating the effect of vegetable decomposition upon the health of man, too much notice has not heretofore been taken of the carbonic acid and kindred stable products given out, and too little attention paid to the energy evolved. In fact, whether from the surface of every seething swamp there be not poured forth streams of that powerful energy which originally fed the growing plants, and which when eliminated within the body of man is known by the name of life. To assume that such energy is powerless is to assert that the mother's heat is not the force that hatches out the egg.

That the theory which attributed all noxious influence to the gaseous resultants of decomposition did not satisfy the requirements of science is shown by the greedy acceptance of the germ theory which now prevails. But this, after all, is but coming one step nearer to the action of that universal energy which is the inseparable concomitant of all material interchange. For has not Dr. Burdon Sanderson well said, "Bacterial life is a middle term between chemical antecedents and consequents"? They reduce all unstable compounds in the world to final stable products, and live with vigor or in apathy in proportion to the effect upon themselves of the energy evolved from the medium they destroy. Thus, too, is produced much of that form of secondary energy recognized as heat of decomposition; and while this heat is known to possess marvelous influence over vegetable germination, it has up to the present been credited with but little action on the life of man.

The gaseous consequents and the bacterial agents have borne the blame of every human ill, while that energy which ruled the universe before the first vegetable cell had varied toward animal functions is allowed to go unchallenged.

If, then, suspicion can be legitimately directed toward this heat as a factor in physiological change hitherto overlooked, it becomes necessary to pursue the subject of heat in all its latest developments.

Dr. Doherty, in his "Organic Philosophy," says: "Light is nothing but the velocity of a force which in slow motion is called heat." From the facts that are known in relation to light it may be possible to deduce by analogy much that is yet unproved with regard to heat.

It has been shown that light consists of certain colors which, when taken together, produce the sensation of light. Each of these colors acts upon certain specialized molecules of the optic nerve, and not upon the remainder, just as Professor Tyndall has shown that the invisible heat rays, "powerful as they are, and sufficient to fuse many metals, can be permitted to enter the eye and to break upon the retina without producing the least luminous impression."

May it not therefore be inferred that heat consists of a series of velocities of force which when taken together produce the sensation of heat, yet each of which is capable of acting upon certain specialized molecules of the nerves of sensation, while being unperceived by the remainder?

Light has been proved by Captain Abney to be the visible velocities of wave lengths from 38,000 to the inch to 60,000, and within this range from 38,000 to 60,000 to the inch all the varied sensations of color are produced. Nevertheless, by the higher velocities, from 60,000 to 120,000 wave lengths to the inch, the great chemical actions of the world are performed. Is it not evident, then, that if the recognition of wave lengths from 38,000 to the inch and upward depended solely upon the subjective sensation of light, all appreciation of them must cease at the 60,000 wave lengths, and that the great powers of the ultra-violet wave lengths must have remained in darkness for ever?

But Captain Abney has also shown that there are measurable wave lengths extending downward from 38,000 to 10,000 to the inch; if, therefore, these are credited with such action only as is recognizable by the subjective sensation of heat, is it not equally possible that powerful influences which change for good or ill the configuration of the molecules of the nerves of sensation may be left unregistered?

It is therefore allowable to infer from this analogy that in the dark region descending from the fading red to the cold of zero there may be many rates of velocity, some of which, harmonizing with some phase of life, produce the most potent physiological effects without at the same time exciting the molecular resistance which corresponds to the sensation of heat.

In other words, is it not probable that in estimating the actions of the forces of nature upon the animal sys-

tem some most subtile influences have been overlooked because unrecorded by the index of the thermometer?

Professor Tait says: "The energy of vibrational radiations is a transformation of the heat of a hot body and can be again frittered down into heat, but in the interval of its passage through space devoid of tangible matter, or even while *passing unabsorbed through tangible matter, it is not necessarily heat.*" And Mr. Pattison Muir in his work on "Thermal Chemistry" asks: "Must all energy which is lost by a changing chemical system during a definite operation make its appearance in the form of heat? Energy appears in chemical operations in forms other than that of heat—electrical energy, for instance. We must distinguish in chemical processes between that part of chemical energy which is freely changeable into other forms and that which can leave the system only in the form of heat."

The most recent researches thus point to the probability that while the bacterium carries on through nature its never ending work of reducing chemical antecedents to chemical consequents, it must as continuously set free energy in forms other than that of heat.

One of the most pregnant discoveries made of late is that which demonstrates that, even in the case of the powerful friction requisite for boring iron, heat ceases to be recognizable as heat when the iron operated on is strongly magnetized: that is, that heat developed by friction in a magnetic field disappears in some form other than heat. By this the idea is suggested that heat energy impinging upon the sentient extremity of a nerve in action may be taken up and carried in a form other than heat to the central brain, just as sound is conveyed in a form other than sound across the interval between the telephone and the receiver; and if the multiple wave lengths which produce the subjective sensation of heat can be thus transferred from the surface to the center, why not fractions of that multiple which when taken together make the whole?

Since, then, science cannot specify the difference between the energy contained in dead carbonic acid and that of the living hydrocarbon, neither can it draw a line more definite than the equator between those series of decompositions which on the one side are termed life and on the other are designated death. In each and all the compound descends from instability toward stability, and in every degradation is energy evolved.

Yet that energy, no matter in what companionship it may be found, or through how many existences it may have transmigrated, has still but one original source, and consequently it is impossible to conceive a condition in which that energy, primarily possessed of such "phenomenal modes of action," can be regarded as absolutely inert.

So far, then, it is claimed that grounds have been established for asserting that from the surface of every decomposing swamp forms of energy must be momentarily poured forth, the potency of which is as yet unknown.

Again, while it is at present impossible to isolate the fractions of energy the sum of which make heat, still it would contribute vastly to the proof of their independent existence if it could be shown that the nerves of sensation are specialized in sections, each reacting separately, to different gradations of heat.

This has been apparently accomplished.

"Dr. Goldscheider, at a meeting on April 9 of the Physiological Society of Berlin, discussed the action of menthol on the sensory nerves. He therefore concluded that the sensations in some places of cold and in other places of heat, produced by menthol, were purely subjective, and consequent on the direct stimulation of *the special nerves of temperature, those usually cognizant of cold* being far more sensitive to its influence than were those adapted to receive impressions of higher temperatures."—*Brit. Med. Journ.*, August 21, 1886.

Here, then, is strong evidence that the sentient nerve endings over the surface of the body are graduated to respond to the various rates of energy that may impinge thereon; and if so, how can it be admitted that the varieties of energy by which these nerve endings are stimulated must be limited to those already identified?

That some such idea has shaped itself in the minds of observers may be gathered from the independent opinions expressed by several of the members of the Cholera Commission of 1885.

Prof. Aitken sums up his valuable contribution in these words:

"Some influence (as yet unknown, and therefore so far mysterious) seems to create in cholera times and places an epidemic activity. It is probable that this may be due rather to some meteorological condition—some peculiar state of the atmosphere, electrical or other—combined with unwholesome conditions of surroundings and conditions of life; a co-existence of physical phenomena rather than anything in the individual. It is well known that electrical conditions such as prevail in a thunderstorm will cause milk to become sour, the formation of the acid being associated with, or due to, the formation of the bacterium lactis, and thus confined to very definite areas."

In the last paragraph lies the key to some of the foregoing mystery.

The mode in which to use it can be learned from the marvelous researches of Pasteur.

It is obvious that if the cause of sourness be the bacterium, the cause of greater sourness will be the bacterium still, and that the reason for the increased reduction by the bacterium of chemical antecedents to chemical consequents, which produces the additional sourness, must lie in some condition affecting the life of the bacterium too.

Pasteur has shown that a fundamental difference exists in the mode of action of the beer and grape ferments when "the introduction of the free oxygen of the atmosphere is permitted and when such introduction is prevented." When free oxygen is admitted, "the ferment shows an activity *even more extraordinary* than it did in the deep vats; the life of the ferment is singularly enhanced, *but* the proportion of the weight of the decomposed sugar to that of the yeast formed is absolutely different in the two cases; while for example in the *deep vats* a kilogramme of ferment sometimes decomposes 70, 80, 100, or even 150 kilogrammes of sugar, in the *shallow* troughs 1 kilogramme of the ferment will be found to correspond to only 5 or 6 kilogrammes of decomposed sugar. In other words, the more free oxygen the yeast ferment consumes, the less is its power as a ferment; the more, on the contrary, the life of the ferment is carried on *without the presence of free oxygen*, the greater is its power of decomposing and of fermenting the saccharine matter."

Here, then, is the clew to the cause of the increased sourness of milk during electrical conditions such as prevail in a thunderstorm. The bacterium lactis evidently finds itself in a situation in which the free oxygen of the atmosphere has, owing to some atomic disturbance in its molecules, become less available as an energy provider.

The organism is consequently compelled to revert to the *condition of the ferment in the deep vats*, and to find in the increased decomposition of the constituents of the milk that energy which is necessary for its existence.

Further, it is known that electricity does affect the condition of oxygen, that the conversion of its molecules from the diatomic to the triatomic state can be brought about by its influence, and that this latter state has been recognized as ozone.

If, then, it can be thus proved that the presence or absence of oxygen so materially alters the mode of existence of microscopic organisms, is it not reasonable to accept changes in the lives of the organisms as evidence of the altered condition of oxygen? And since certain conditions of free energy are thus found to interfere with the mode of nutrition of the minutest forms of life, can it be doubted that similar forces may exercise a material influence upon the more complex being, who, after all, is but a larger multiple of the original protoplasmic element?

Thus it becomes possible that energy existing in forms other than those of light or heat exerts a power which has up to the present been ignored.

By this reasoning too, based on the altered mode of nutrition of the bacterium lactis during a thunderstorm, much that has been hitherto obscure in the history of the diseases, or blights, of the vegetable world becomes intelligible.

When it is found that all the bacteria lactis over a considerable area at the same moment change their mode of existence, and, from leading a comparatively sluggish life in the milk substance, suddenly break up almost the whole of that substance at a time when electrical disturbances are present, it is easily conceivable that in the case of potato blight, which is almost invariably accompanied by obvious atmospheric changes, like conditions may arise. In fact, that the universally present bacteria, which, under ordinary circumstances, continue to exist without apparent injury to the tuber and leaves with which they are in contact, may, when driven by the stress of altered atmospheric conditions, turn upon the tissues of the plant for nutrition as the bacterium lactis upon the milk.

If, then, these effects of certain unrecognized forms of energy be established, it will go far to help the elucidation of the mysterious subject of cholera.

Dr. Bryden, from prolonged study of the cholera statistics of India, arrived at the following conclusions: "That the disease was endemic in the Soonderbunds, and that its cause was *earth-born* and *air-born*"—to repeat the words of Prof. Aitken, "due rather to some meteorological condition, some peculiar state of the atmosphere, to a co-existence of physical phenomena;" and Deputy Surgeon-General Marston has added: "Cholera spreads along rivers, but against their current in Bengal. It invariably advances from Bengal proper to the Himalayas, and never the reverse."

Here, then, are the conclusions arrived at by some of the most skilled observers on this subject.

It is thus admitted that cholera is endemic in the Soonderbunds, and that its track from thence lies in a northwesterly direction. That is, that its home is a surface of 12,000 square miles of decomposing tropical vegetation, and its direction that from whence the Ganges and its tributaries flow.

From this it may be inferred that its cause is such that it can be carried atmospherically, and that its course is the line of the least resistance.

Were the cause of cholera solid or liquid, it would doubtless long ere this have been demonstrated. Were it gaseous, it must follow the law of the diffusion of gases. What, then, remains to be sought for over the surface of the Soonderbunds? Naught but some form of that universal energy which fell as a sunbeam upon the growing plant, but which, when filtered through its substance, is evolved in a less vivid but still a potent form from its decaying structure.

That such returned energy has the power of incorporating itself with water, till it passes upward as a vapor, every steaming dung heap shows, and in what prodigious force it can be again eliminated may be understood from the calculation of Prof. Haughton, that the condensation of vapor sufficient to afford one gallon of rainfall gives out sufficient heat to melt 45 pounds of cast iron.

From this may be estimated the enormous output of bottom heat which must day and night pass from a decomposing surface of 12,000 square miles to the vapor-carrying air above.

To comprehend the distance to which this energy may be transported before doing visible work it is only necessary to consider the Gulf Stream, which is described by Prof. Tait as "a vast convection current whereby the solar heat of the tropics is carried into the North Atlantic." And to measure the work done thereby it needs but to weigh the luxuriant vegetation of the United Kingdom against the frigid barrenness of Labrador.

If, then, such vast stores of force can be transported from the tropics to England, it cannot be irrational to assert that from the surface of the Soonderbunds, and like places, much of the energy of decomposition must ascend with the rising vapor, and that whether drawn landward by the heated earth surface, or pushed inward before the advancing monsoon, this vapor must follow the line of least resistance along the course of the river beds.

Again, when it is remembered how intense are the effects on the nerves of the animal body of the chemical affinity evolved as electricity from a few square inches of decomposing zinc, it may well be contended that the energy of chemical affinity evolved from so great an area of decomposing organic substances cannot be innocuous, and the fact of its action not being acknowledged by the subjective sense of feeling is no proof that it is non-existent.

Thus it becomes conceivable how the energy evolved in the Soonderbunds may, when vapor-borne across the interval, affect the inhabitants of Oude, and so alter the individual condition as to admit of local causes producing foreign effects.

Many of the most careful observers have asserted that malarious fevers arose from chill. Yet, while this did not solve the question, it at least established one fact, that malarious fevers arose under circumstances which necessitated vapor condensation, one gallon of which would set free energy sufficient to melt forty-five pounds of cast iron.

Familiarity with malaria will furnish many arguments in support of the contention that fever infection is at least coincident with vapor condensation. A boat's crew ashore at night on a West African station will often be affected, while those but a few miles seaward will remain exempt.

In the deep valleys of Zululand leading from the St. Lucia swamp, fever is contracted at a distance of many miles inland, while high ground much nearer to the swamp may be occupied with impunity. In the Terai, at the foot of the Himalayas, a night's sojourn brings to the unseasoned traveler certain fever, while a day journey is almost free from risk.

Since, then, the search for a material cause of cholera and of malaria has been as unsuccessful as if one sought a material cause for sunstroke, it may legitimately be suggested that, as the more rapidly fatal affection is the result of the action of direct solar energy upon the sentient nerve-endings, so the less rapid maladies may result from subordinate rates of the same energy acting upon subdivisions of the nerve-endings, which, as Dr. Goldscheider has shown, are specialized to respond to lower velocities of that force, and that the chill to which so many attribute the origin of fever is really the acknowledgment, by what Dr. Goldscheider terms "the special nerves of temperature usually cognizant of cold," of that obscure energy hitherto unregarded as a factor in the production of disease, but which the investigations of thermo-electricity may one day bring within the ken of man.—

Military Prison, Dublin. —*Nature.*

## SEPARATION AND ESTIMATION OF BORIC ACID.*

By F. A. Gooch.

In all successful methods for the estimation of boric acid, its comparative isolation is a necessary preliminary. Fortunately the removal of nearly everything which interferes seriously with the proper execution of methods is not particularly arduous, but of ordinarily occurring substances, two, silica and alumina, both very commonly associated with boric acid, are especially annoying in this regard. In the separation of alumina the trouble lies in the tendency of the precipitated hydrate to carry and retain boric acid,† so that the two cannot be parted by means of ammonia or ammonia salts. With silica, the difficulty is in removing it completely.

The volatility of boric acid stands, of course, absolutely in the way of treating with acid and evaporating to dryness, and every chemist knows the vainness of attempting to precipitate silica by means of ammonia, ammonia salts, or zinc oxide in ammonia. In Stromeyer's method‡ the presence of silica is peculiarly harmful, since in passing to the condition of potassium fluo-silicate this substance nearly quadruples its weight, and to free the potassium fluo-borate from containing fluo-silicate requires, according to Fresenius,§ at least six treatments by solution in boiling water, the addition of ammonia, and evaporation to dryness. Wohler‖ recommends evaporating the hydrochloric acid solution to dryness in a flask fitted to a condenser, collecting the distillate, reuniting the latter with the residue, and filtering from silica, and the operation is successful so far as the complete removal of silica is concerned, but the alumina, if present, is still in condition to give annoyance, and the other bases are yet to be separated.

Advantage has long been taken of the volatility of free boric acid with hydrofluoric acid or with alcohol to secure its removal from fixed substances, but so far as I know, no attempt has been made heretofore to secure its complete volatilization and estimation in the distillate. The experiments which I proceed to describe are the result of an effort to accomplish this end.

Aside from the difficulties in manipulation and in the construction of apparatus which the use of hydrofluoric acid would involve, this reagent is otherwise plainly inapplicable to the purpose in view, and of other agents with which boric acid is known to volatilize freely, methyl alcohol seems to present the most desirable qualities. Methyl alcohol, ethyl alcohol, and water are effective in the order in which they are named. Thus to volatilize 1 grm. of boric acid—the equivalent, speaking roughly, of about 0·5 grm. of boric anhydride—two treatments with 10 cm. of methyl alcohol and evaporation to dryness in each case were adequate. For the volatilization of 0·2 grm. of boric acid were required two treatments of 10 cm. each of ethyl alcohol, succeeding an evaporation with 50 cm. of the same alcohol; and the residue of five evaporations of water over 0·4 grm. of boric acid, taking in each case 50 cm. of water, followed by ignition, weighed 0·08 grm., or one-fifth of the original weight. In the presence of water, methyl alcohol is not equally effective. Amyl alcohol and sulphuric acid restrain its action similarly, doubtless by dilution simply, and hydrochloric acid seems to possess no advantage over water alone in developing the volatility of boric acid.

As an example, an experiment may serve in which a solution of 0·4 grm. of boric acid in 50 cm. of water, after being heated three times successively with 25 cm. of methyl alcohol until the boiling point rose in every case nearly to that of water, and then evaporated to dryness, left a large residue which disappeared with a single charge of 25 cm. of methyl alcohol applied by itself.

From the residue of the evaporation of borax with

* Proceedings of the American Academy of Arts and Sciences, 1886–87.

† Wohler, *Ann. d. Chem. u. Pharm.*, cxli., 268.

‡ *Ann. d. Chem. u. Pharm.*, c., 82.

§ "Handbook of Mineral Analysis," under datholite.

‖ "Quant. Chem. Anal.," p. 424.

hydrochloric, nitric, or acetic acid, methyl alcohol, as would naturally be predicted, volatilizes the boric acid freely, though the presence of foreign material acts to a certain degree protectively and tends to diminish the rapidity with which the alcohol would otherwise effect extraction and volatilization. In case, however, that acetic acid is used to break up the borate, the tendency of sodic acetate to lose acid and become alkaline simply by exposure to evaporation in its aqueous solution makes it necessary to insure the acidity of the residue of evaporation by adding a drop or two of acetic acid before repeating the treatment with methyl alcohol.

On the whole, methyl alcohol shows itself to be an excellent agent by which to secure the volatilization of boric acid.

To retain free boric acid, magnesium oxide naturally suggests itself. According to Marignac* it is effective, and, if in the course of analysis it may have been partly converted to the chloride, it is easily regenerated by the action of heat and moisture. Marignac, it will be remembered, makes use of magnesia mixture—the chlorides of ammonium and magnesium with free ammonia—to fix the boric acid, evaporating the solution to dryness, igniting, extracting with boiling water, filtering, and weighing the residue, while the filtrate is again treated as before to recover traces of the borate which have yielded to the solvent action of the water.

During the drying and ignition the magnesium chloride yields hydrochloric acid, and it would seem scarcely possible that the magnesium borate should fail to show some loss of boric acid when both hydrochloric acid and moisture exert their action. Further, the presence of ammonia during evaporation does not prevent the volatilization of boric acid,† and Marignac regards the addition of it from time to time as of doubtful use. So it appears natural to look for some loss under such conditions, and Marignac fully recognizes the fact that the apparent accuracy of his method is due to the balancing of errors, the inclusion of foreign matter by the magnesium borate, and the deficiency of the magnesia when precipitated as ammonio-magnesium phosphate, together compensating for the loss of boric acid by volatilization.

To bring the matter to the test, the following experiments were made. In them and in all succeeding experiments the boric acid was weighed in solution, the standard of this having been fixed by dissolving in a known weight of water a known weight of fused boric anhydride prepared in a state of purity by frequent recrystallization. The magnesium oxide employed was made from the pure chloride by precipitating by ammonium carbonate and igniting, and was free from lime and alkalies, and, as far as could be determined, otherwise pure.

The whole operation of each experiment was conducted in one vessel, so as to avoid transfers. In all cases a weighed platinum crucible of 100 cm. capacity received a weighed portion of magnesia, and after ignition and subsequent weighing, the weighed solution of boric acid was introduced. In experiments 1 to 4 the magnesia was thoroughly stirred in the solution of boric acid, the evaporation carried at once to dryness, and the crucible and residue ignited and weighed. In experiments 5 to 8, the magnesia was dissolved, after the addition of the boric acid, in hydrochloric acid sufficient in amount to prevent the precipitation of magnesium hydrate on the subsequent addition of ammonia, ammonia introduced in considerable excess in 7 and 8, in distinct excess in 5 and 6, the whole evaporated and ignited, the residue moistened and again ignited, and this last treatment repeated until the residue ceased to yield vapor of hydrochloric acid when heated.

| | $B_2O_3$ taken, Grm. | MgO taken, Grm. | $MgO+B_2O_3$ found, Grm. | $B_2O_3$ found, Grm. | Error, Grm. |
|---|---|---|---|---|---|
| (1) | 0·1734 | 0·5005 | 0·6607 | 0·1602 | 0·0132— |
| (2) | 0·1804 | 0·4973 | 0·6660 | 0·1687 | 0·0117— |
| (3) | 0·1793 | 0·4949 | 0·6640 | 0·1691 | 0·0102— |
| (4) | 0·1794 | 0·4941 | 0·6627 | 0·1686 | 0·0108— |
| (5) | 0·1807 | 0·4984 | 0·6542 | 0·1558 | 0 0249— |
| (6) | 0·1789 | 0·4974 | 0·6687 | 0·1560 | 0·0229— |
| (7) | 0·1806 | 0·4944 | 0·6684 | 0·1740 | 0·0066— |
| (8) | 0·1789 | 0·4959 | 0·6672 | 0·1713 | 0·0076— |

From these results it appears plain that under the conditions of the experiments neither magnesia alone nor the magnesia mixture is efficient in fixing boric acid, but in experiments 7 and 8, in which ammonia was employed in large excess, the loss of boric acid is least, so that it would seem to be the case that though ammonia is not a perfect preventive of volatilization it does exert a restraining action on the boric acid. That the magnesia mixture should be incapable of retaining entirely the boric acid present is, as has been pointed out, not surprising, but that the loss should be so great is rather startling, and more than suggests that the errors of Marignac's process are seriously excessive.

The failure of magnesium oxide to hold back boric acid under the conditions of the experiment must be due to a cause other than that which determines the loss during the evaporation and ignition of the magnesia mixture, and for this it is natural to turn to the insolubility of the oxide—a quality likely to oppose some difficulty in the way of establishing complete contact between the boric acid and the magnesia during a short exposure. Direct tests of this point showed distinctly that mixtures of boric acid in water and magnesia, when submitted at once to distillation, yielded boric acid to the distillate, but that, if the mixtures were permitted to stand some hours before distilling, the oxide passed to the semi-gelatinous condition of the hydrate, and retained the boric acid so firmly that turmeric failed to show the presence of the latter in the distillate.

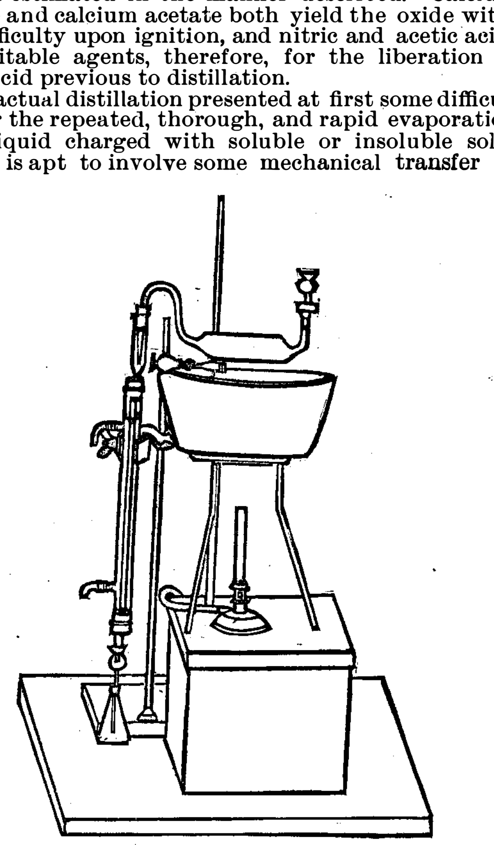
It is plain, therefore, that with sufficient preliminary exposure, magnesia might be relied upon to retain boric acid, but inasmuch as long and perhaps somewhat indefinite periods of waiting are objectionable in any analytical process, it was thought best to try the effect of substituting lime for magnesia. Experiments 9 to 12, conducted like the previous ones, excepting only the use of carefully prepared and ignited calcium oxide instead of magnesium oxide, were made with this end in view.

| | $B_2O_3$ taken, Grm. | CaO taken, Grm. | $CaO+B_3O_3$ found, Grm. | $B_2O$ found, Grm. | Error, Grm. |
|---|---|---|---|---|---|
| (9) | 0·1810 | 0·9737 | 1·1560 | 0·1823 | 0·0013+ |
| (10) | 0·1819 | 0·9750 | 1·1583 | 0·1833 | 0·0014+ |
| (11) | 0·1808 | 0·9922 | 1·1810 | 0·1818 | 0·0010+ |
| (12) | 0·1833 | 0·9715 | 1·1560 | 0·1845 | 0·0012+ |

These figures indicate sufficiently that there is no loss of boric acid by volatilization when its aqueous solution is evaporated in contact with calcium hydrate; but, inasmuch as the comparative solubility of the latter is the quality which makes it effective where magnesia is not, it seemed desirable to test the action of calcium hydrate in alcoholic solutions, in which it is very insoluble. The experiment showed that when the solution of boric acid in methyl or ethyl alcohol is put upon lime and distilled at once, loss is apt to take place, and sometimes to a very considerable amount, but that a short period of digestion with occasional stirring—from five to fifteen minutes—is sufficient to obviate danger of volatilization of boric acid.

It appears, therefore, that free boric acid being easily volatilized by means of methyl alcohol and fixed completely by calcic hydrate, the separation of the acid from almost everything with which it occurs ordinarily and its estimation subsequently depend only upon the practicability of distilling it from its compounds in such company that it may be retained by lime and its amount determined by the increase in the weight of the latter. Unlike magnesium chloride, calcium chloride does not yield its chlorine readily under the action of heat and moisture naturally retained; so that hydrochloric acid must not be present with boric acid which is to be estimated in the manner described. Calcium nitrate and calcium acetate both yield the oxide without difficulty upon ignition, and nitric and acetic acids are suitable agents, therefore, for the liberation of boric acid previous to distillation.

The actual distillation presented at first some difficulty—for the repeated, thorough, and rapid evaporation of a liquid charged with soluble or insoluble solid matter is apt to involve some mechanical transfer to



the distillate of material which should remain in the residue—but the device of the following description solves the problem successfully.

The apparatus, which is shown in the accompanying cut, consists essentially of a retort, condenser, and bath for heating. For the last I have used a paraffin bath, as being on the whole the most convenient. The condenser is set vertically, to facilitate changing the level of the retort within the bath, and to secure at the same time continual and thorough washing of the tube by its own condensations. The retort, somewhat like the well known drying tube of Liebig in general shape, is easily made of a pipette by bending the tube at one end to a right angle, at the other to a goose neck, as shown. To the former end is fitted, by a rubber stopper or section of tubing, a glass funnel tube provided with a stop cock. The end of the goose neck passes tightly through a rubber stopper in the upper end of the condensing tube. This is essentially the apparatus, but it is convenient to attach to receive the distillate a small Erlenmeyer flask, which moves with the condenser and is joined to it, in the manner indicated in the figure, by means of a thistle tube and a rubber stopper grooved to permit the free passage of air. In carrying out a distillation, the liquid to be distilled is introduced into the retort either by the funnel tube or previous to its insertion, the glass cock is closed, the water started through the condenser, and the retort lowered into the hot paraffin, care being taken to begin the operation with the retort not more than half full and so inclined that only the rear dips below the surface of the bath. If the precaution to heat the retort at the start in this manner be overlooked, it may sometimes happen that the sudden and violent expulsion of the air through the liquid will carry portions of it bodily into the goose neck, and even into the condenser. With this point considered, the remainder of the operation presents no difficulty, and requires little care.

The size of the retort may suited, of course, to the particular case in hand, but for most purposes a 200 cm. pipette makes a retort of convenient dimensions, neither too large for the distillation of small charges nor too small to permit the treatment of 100 cm. of liquid comfortably. The tube of the goose neck should be wide enough to prevent the formation of bubbles in it; 0·7 cm. is a good measure for the interior diameter. It is of advantage to heat the bath to a point considerably above the temperature at which the liquid which is to be distilled boils—something between 130° C. and 140° C. does very well for water, and is not too high for methyl alcohol—and under such circumstances, and when the retort is entirely submerged, it often happens that evaporation takes place with extreme rapidity from the surface of the liquid in perfect quiet, without actual boiling.

With such an apparatus the following experiments were made. The boric acid was weighed, as before, in solution, and to bring the condition of the experiment to that of an actual analysis, 1 gramme of pure sodium hydrate was added in solution, nitric acid or acetic acid to acidity and a little more, and the whole was introduced into the retort and distilled to dryness.

In those experiments in which nitric acid was employed, the methyl alcohol was introduced upon the residue thus dried in six successive portions of 10 cm. each, and distilled to dryness; but in order to break up the residue of sodium nitrate, which by its insolubility might effect to some extent the protection of the boric acid from the action of the alcohol, 2 cm. of water were introduced and evaporated between the second and third, and again between the fourth and fifth distillations.

When acetic acid was made use of to free the boric acid, the six distillations with methyl alcohol were made as before; but, sodium acetate being soluble in methyl alcohol, the intermediate treatments with water were unnecessary. With the fourth portion of methyl alcohol a few drops of acetic acid were added to preserve the acidity of the residue, which, as has been pointed out, tends to become alkaline under the treatment.

The residues of both processes of treatment were found to be free from boric acid by the exceedingly delicate test with turmeric, care being taken in the series of experiments in which nitric acid was used to oxidize nitrites by means of bromine (expelling the latter before making the test), and in the acetic acid series to acidify with hydrochloric acid sufficiently to counteract the tendency of the acetate by itself to brown the turmeric on evaporation.

The lime to retain the boric acid in the distillate was ignited in the crucible in which the evaporation of the distillate was to be made subsequently, and then transferred to the receiving flask attached to the condenser, so that the boric acid might be fixed during the distillation. To prevent the caking of the lime by the action of the alcohol, it was slaked with a little water before the distillation was begun,

In experiments 13 to 16 nitric acid was employed, and in 17 to 20 acetic acid was used, with the precaution noted, to liberate the boric acid.

In experiments 13 to 16 the mean error amounts to 0·0012 + gramme; the experiments 17 to 20 the mean error is a little more than 0·0010+ gramme. Throughout the entire series of experiments the tendency to yield figures slightly larger than the truth is manifest,

| | $B_2O_3$ taken, Grm. | CaO taken, Grm. | $B_2O_3+CaO$ found, Grm. | $B_2O_3$ found, Grm. | Error, Grm. |
|---|---|---|---|---|---|
| (13) | 0·1738 | 0·9647 | 1·1392 | 0·1745 | 0·0007+ |
| (14) | 0·1806 | 0·9639 | 1·1456 | 0·1817 | 0·0011+ |
| (15) | 0·1779 | 0·9665 | 1·1450 | 0·1785 | 0·0006+ |
| (16) | .0·1824 | 0·9739 | 1·1587 | 0·1848 | 0·0024+ |
| (17) | 0·1806 | 1·4559 | 1·6371 | 0·1812 | 0·0006+ |
| (18) | 0·1812 | 0 9720 | 1·1543 | 0·1823 | 0·0011+ |
| (19) | 0·1788 | 0·9986 | 1·1781 | 0·1795 | 0·0007+ |
| (20) | 0·1813 | 0·9527 | 1·1358 | 0·1831 | 0·0018+ |

but the error is quite within legitimate limits. The greatest care was taken to secure similarity of conditions under which the crucible and lime were weighed before and after the evaporation and absorption of boric acid, and the weight after ignition was taken in every case after cooling over sulphuric acid during a definite period of ten minutes, in order to eliminate as far as possible the effect of atmospheric condensation upon a large surface of platinum. Ignitions were always finished over the blast lamp, and constancy of weights secured.

The results of both modes of treatment are, on the whole, satisfactory, and equally so.

In the presence of chlorides, it is of course impossible to employ nitric acid to free the boric acid. Oxalic, citric, and tartaric acids also liberate hydrochloric acid to a considerable extent from alkaline chlorides. It was found, however, that when acetic acid was distilled over sodium and potassium chlorides, only traces of hydrochloric acid passed into the distillate, and experiments 21 to 23 were made to determine whether these amounts are sufficient to vitiate the separation of boric acid from alkaline chlorides by distillation in the presence of free acetic acid. The details of treatment were identical with those of experiments 17 to 20, excepting only the addition of 0·5 gramme of sodium chloride to each portion before distillation.

| | $B_2O_3$ taken, Grm. | CaO taken, Grm. | $B_2O_3+CaO$ found, Grm. | $B_2O_3$ found, Grm. | Error, Grm. |
|---|---|---|---|---|---|
| (21) | 0·1834 | 0·9842 | 1·1675 | 0·1833 | 0·0001— |
| (22) | 0·1831 | 0·9755 | 1·1593 | 0·1838 | 0·0007+ |
| (23) | 0·1761 | 0·9740 | 1·1523 | 0·1783 | 0·0022+ |

The mean error of these results is about 0·0009+ gramme, and it is plain that the presence of sodium chloride does not materally change the conditions of the experiment. There seems, therefore, to be no reason why boric acid may not be separated by distillation from alkaline chlorides in presence of free acetic acid; but it was found that the presence of any considerable amount of potassium acetate is disadvantageous. Sodium acetate to a reasonable amount does not interfere with the favorable progress of the separation; but potassium acetate appears to require a much higher temperature for the expulsion of its water, and longer distillation.

When, therefore, chlorides are present in the salts from which boric acid is to be removed by distillation, the choice is open between two methods. The distillation may be made directly with an excess of acetic acid; or the hydrochloric acid may be first removed by means of silver nitrate, and the distillation of the filtrate proceeded with at once, or after precipitation of the excess of silver salt by means of sodium hydrate or carbonate, care being taken to acidify again sufficiently with nitric acid after the removal of the silver. Of these two modes of proceeding, I incline to the treatment with nitric acid and the removal of the chlorine by precipitation; and this method has been used with success by others as well as myself, for some months, in the analysis of waters carrying boric acid and natural borates.

The process in either modification is fairly accurate and easily executed, and admits of very wide applica-

* *Zeit. fur Anal. Chem.*, i., 406.
† Rose, *Pogg. Ann.*, lxxx., 262.

tion. Insoluble compounds in which the boric acid is to be determined may be dissolved in nitric acid at once, or, if necessary, first fused with sodium carbonate; and, fortunately, nearly everything which is volatile in the subsequent treatment and capable of forming with lime compounds not easily decomposable by heat may be removed by known processes. The combination of fluorine, silica, and boric acid is perhaps most difficult to treat; but the precipitation and removal of the first as calcium fluoride from the aqueous solution of a fusion in alkaline carbonate may, it is believed, be effected with care, and the mode of procedure from that point is simple.

The number of distillations necessary depends, of course, upon the amount of boric acid treated. To remove 0·2 gramme of boric anhydride completely to the distillate, six charges of methyl alcohol, of 10 cm. each, proved, as we have seen, to be ample.

The apparatus by the aid of which the distillation processes which have been described were carried out has found useful application in a number of other processes. In the determination of free and albumenoid ammonia in waters which can be boiled quietly with difficulty, in the methods of estimating hydrofluoric acid which involve the expulsion of silicon fluoride from a mixture of the fluoride with sulphuric acid and silica, in the separation of iodine from bromides and chlorides by distilling with ferric sulphate and sulphuric acid, and of bromine from chlorides by means of permanganic acid, it has proved of value, and will doubtless be found convenient in many analytical processes in which quantitative separations by the distillation of liquids liable to spatter or boil explosively are involved.

## ANALYSIS OF "PURE ZINC" MADE BY THE BERTHA ZINC COMPANY, PULASKI COUNTY, VIRGINIA.

By G. B. Bird.

The above mentioned company manufactures from ore, essentially calamine, an excellent grade of zinc, which afforded on analysis (by F. P. D., in 1881) the following:

| | |
|---|---|
| Lead | 0·0500 |
| Silicon | 0·0168 |
| Iron | 0·0140 |
| Carbon | 0·0580 |
| Arsenic | 0·0001 |
| Sulphur | ... |
| Zinc, by diff | 99·8611 |

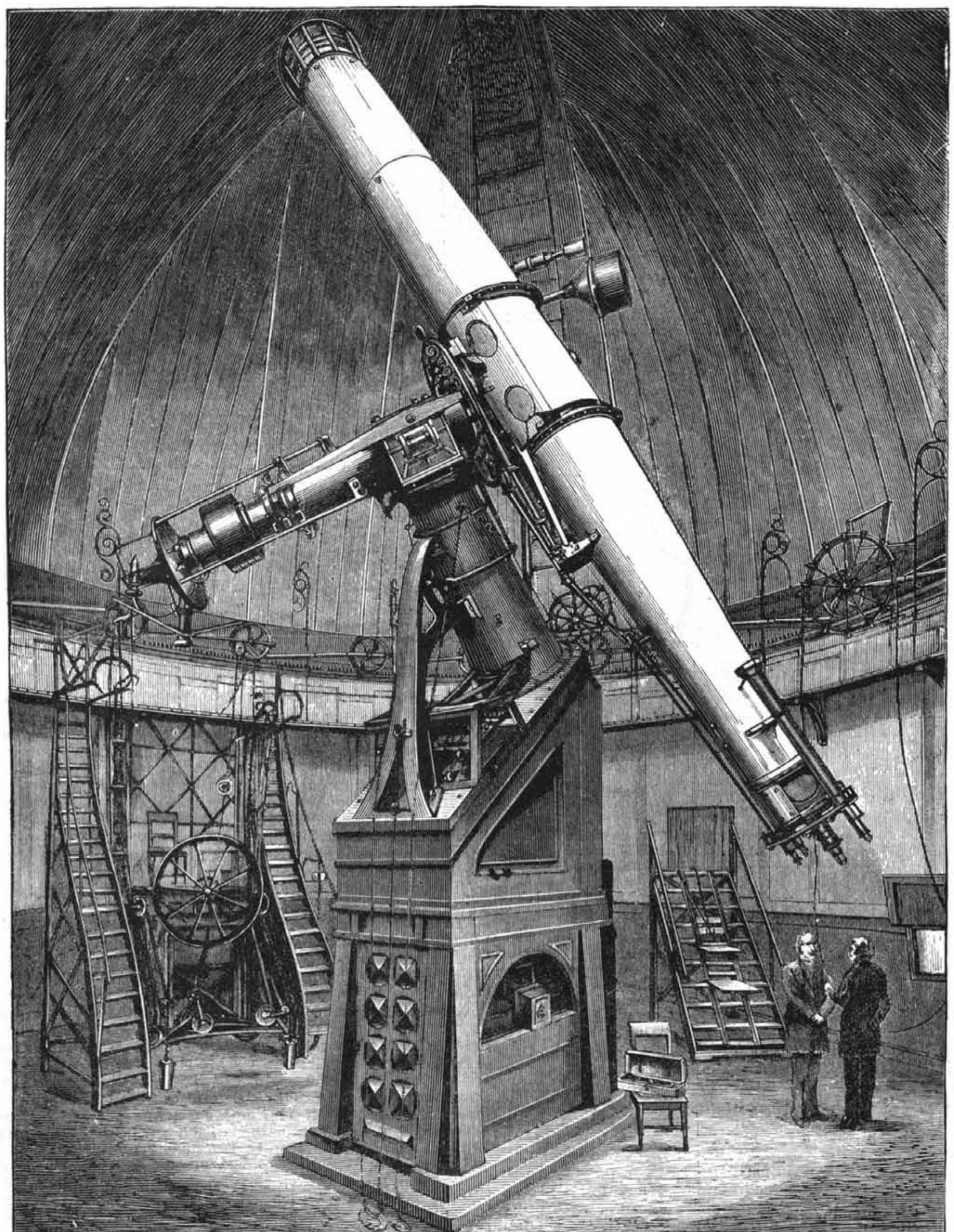
Through the kindness of Mr. Thos. Jones, superintendent, a portion of the commercial spelter was charged into one of the upper retorts of the furnace and redistilled at a less heat. Analysis of which gave:

| | |
|---|---|
| Lead | 0·0225 |
| Silicon | 0·0019 |
| Iron | 0·0121 |
| Carbon | none. |
| Arsenic | none. |
| Sulphur | 0·0006 |
| Zinc, by diff | 99·9629 |

It, therefore, appears that while other impurities are largely removed, the small amount of iron is scarcely diminished by redistillation from a fire clay retort with iron front, such as is usually employed in the Belgian process. This metal answers excellently for most of the laboratory processes in which zinc of high degree of purity is demanded.—*Amer. Chem. Jour.*

## THE GREAT REFRACTOR OF THE VIENNA OBSERVATORY.

The successful application of photography to the representation of the starry heavens has awakened universal interest in the work of astronomers, and we believe, therefore, that we comply with the wishes of many when we illustrate one of those immense telescopes which enable astronomers to explore the vast distances of the universe from which light reaches us after a journey of thousands or even millions of years.



THE GREAT REFRACTOR OF THE VIENNA OBSERVATORY.

Until lately the gigantic telescope in the Vienna observatory was the largest in the world, for it surpassed in size even the Washington refractor, in comparison with which all other telescopes had seemed like dwarfs, but it did not enjoy this reputation long, for the construction of the Vienna telescope seemed to call forth a universal competition for the possession of the largest instrument, and several observatories ordered telescopes of dimensions equal to or larger than the one in Vienna. The diameter of the lens in the Vienna instrument is 27 inches, of that in the telescope at Pulkowa (near St. Petersburg) 30 inches, and of the lens in the refractor in the Lick Observatory, California, 36 inches.

As the accompanying cut may not give a correct idea of the proportions of the Vienna telescope, we will give the following figures: The length of the tube is about 36 ft., and, with its movable axis and counterweights, it weighs about 10,000 lb. The entire instrument, with its cast iron base, weighs more than 36,000 lb.

This telescope was constructed by Howard Grubb, of Dublin, and cost in round numbers $33,600. The entire instrument, including the protecting dome, etc., and exclusive of the foundation of masonry, cost about $84,000.—*Illustrirte Zeitung.*

## A CARD—CORRECTION OF ESTIMATE OF COST.

"*Improved Methods of Heating Railway Trains,*" Scientific American Supplement, April 9. By the inadvertency of a misplacement of the decimal point, the cost of heating a standard passenger car per hour was made to read 10$\frac{5}{10}$ cts.; the average price of coal per lb. is 0·00115 ct. per lb., and not 0·0115 ct., and for $9\frac{1}{3}$ lb. of coal consumed per hour per car, it would amount to 0·01073 ct., or one cent per hour per car, which is the correct result. The error was discovered after the edition had gone to press, too late for correction. The mistake was made by the writer, and not by the printer.—

C. Powell Karr, C.E.

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