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The Editor is always glad to receive for examination illustrated articles on subjects of timely interest. If the photographs are *sharp*, the articles *short*, and the facts *authentic*, the contributions will receive special attention. Accepted articles will be paid for at regular space rates.

RETROSPECT OF THE YEAR 1903.

RADIUM.

In any review of the scientific events of the year that has just drawn to its close, it is certain that the determination of the extraordinary properties of radium should hold the first place both in point of fascinating interest and of far-reaching effect. The new element possesses so many startling properties, some of which threaten to overturn our whole system of chemical physics, that it easily takes rank as the notable scientific discovery of the year, and promises to be the scientific sensation of the twentieth century. The story of the discovery of the new element is too well known to call for any repetition here. Let it suffice to say that after months of patient research, the story of which is one of the most interesting in the annals of laboratory work, M. Curie and his wife succeeded in precipitating a few crystals of salt, whose properties were so subversive of many of our accepted theories of force and matter as to produce a veritable panic among both masters and disciples in the world of natural physics. It is impossible within the limits of the present review to enter in detail into a description, to say nothing of a discussion, of the new element; but there are two of its properties which, because of the fact that they seem to completely overturn two fundamental propositions in natural science, serve to give to radium its chief interest. In the first place, then, it has been proved that radium has a temperature which is a few degrees above that of the atmosphere and, wonderful to relate, *that it maintains this relative temperature constantly without any sensible loss of weight;* that is to say, the loss of weight is so infinitesimally small that the figures which express it become purely symbolical. Now, here is a fact which alone was sufficient to strike a staggering blow to one of the foundation postulates of modern science, namely, the theory of the conservation of energy. It was as though M. Curie had held up to the view of the world a small fragment of burning coal which burned but was never consumed, or was consumed so slowly that according to an estimate of the loss of weight by radium made by Becquerel it would take thousands of millions of years before it was entirely burned away. We were but just recovering from the first rude shock, when Prof. Ramsay rendered confusion worse confounded by stating that he had been able to find in the spectrum of the gaseous emanations of radium the characteristic yellow line of helium. He promptly announced this discovery before a learned society, and in the course of his address did not hesitate to voice broadly the thought that must have been uppermost in the mind of his audience, when he exclaimed, "What is this but an actual case of that transmutation of one element into another in which the ancient alchemist believed?" It is natural that in the presence of these disturbing facts, the scientist should search for some explanation which will reconcile the apparent contradictions, and permit our present theories of force and matter to remain as part of our scientific creed. Thus it has been suggested that radium possesses the power of intercepting and making manifest certain invisible and hitherto undetected rays of the sun, and that the wonderful heat phenomena displayed by the new substance are derived from the sun—radium playing the same part with regard to the sun that the fluoroscope does to the X-rays. The mystery of the transformation of radium into helium is more difficult of solution, and, indeed, no explanation that is worthy of consideration has been offered. It is true, however, that the presence of the helium line in the spectra both of radium vapor and the sun, and the possession by the ultra-violet rays of the sun and of radium rays of the same curative qualities, suggest that they have a common origin. The new element emanates three different kinds of rays, one of which travels at the speed of 100,000 miles per second. It is already recognized as likely to have a useful place in the treatment of certain diseases, particularly those that lie near the surface of the body. If small animals are exposed to its action for a few hours, it will prove fatal, if not during the application, at least within a measurable time thereafter. Its discoverer had occasion to carry a small tube containing radium in his vest pocket during a journey to London; and not many days thereafter a painful and troublesome sore developed on the surface of the body beneath the vest pocket. It renders luminous certain precious stones, and will instantly detect the true from the false diamond, the latter refusing to respond to its luminous influence. It is probably the most precious substance in the world today. A few weeks ago M. Curie stated that it was worth three thousand times its weight in gold; to-day, as the result of the disclosure of its wonderful qualities and the increasing demand for the smallest portion of it for scientific and other purposes, its price has risen until it is now worth five thousand times its weight in gold. It is idle to speculate as to the future. It will be time to do that when we have solved the momentous scientific problems that are presented by this, the most wonderful of all known substances.

MERCHANT MARINE.

The most notable event of the year in the American merchant marine was the launch, early in the year, of the "Minnesota," by far the largest ship ever built in this country. She has a length over all of 630 feet, a breadth of 73 feet 6 inches, and a molded depth of 56 feet. Toward the close of the year, however, there was launched for the White Star Company what is considerably the biggest ship ever constructed. This is the "Baltic," which lacks only 200 tons of having 40,000 displacement on her maximum load draft. She is 725 feet 9 inches in length, 75 feet broad, and 49 feet in molded depth. Previous to her advent the "Kaiser Wilhelm II.," which made her maiden trip during the year, was the longest ship, being 706 feet 6 inches in length, 72 feet in beam, and 44 feet in molded depth. A notable event is the subsidizing of the Cunard Line by the British government, and their loaning to that company of the necessary capital for the construction of two great steamships, which are to surpass everything afloat in size and speed. These vessels will be nearly 800 feet in length by 80 feet in beam, and with 70,000 horse power, and are expected to reach a speed of 26 knots an hour. The turbine continues to make progress in the merchant marine. The turbine cross-channel steamer "Queen" is running successfully and has shown a speed of 22 knots an hour, while the Cunard Company have organized a commission of leading marine engineers that is now engaged in making an exhaustive inquiry into the capabilities of the steam turbine, with a view to placing it in the new ships. The publication of their report should form one of the most important engineering documents of the year 1904. The most decided step in the application of the turbine to ocean-going ships was the placing of a contract by the Allan Line for a large transatlantic liner, to be propelled by this type of engine. Although the vessel is to have the moderate speed of only 18 knots, the great size of the ship, and the fact that she will have to meet the wind and weather of the Western Ocean, will definitely settle the status of the turbine in regard to ocean-going ships. An event occurred during the year in the propeller experiments with the British armored cruiser "Drake," which promises to exert a powerful influence upon the future speed of both war and merchant vessels. The "Drake" was designed for and made a speed of 23 knots, with propellers of the normal, narrow-bladed type. On substituting propellers with 30 per cent. more area, the ship made a knot more speed (24.1 knots) with the same horse power. To make the additional 1.1 knots with the old propellers would have required 10,000 more horse power. The propeller is a fruitful field, evidently, for experiment.

ELECTRIC TRACTION.

Unquestionably the event of the year in the field of electric traction was the brilliantly successful culmination of the experiments in high-speed electric traction in Germany. The trials, which had been discontinued the year before because of the weakness of the track, were taken up again after the track had been rebuilt, and the speed was increased in successive trials. Finally the 100-ton experimental car, taking 14,000-volt current from the line, ran from Berlin to Zossen, a distance of 14 miles, at an average speed of 107 miles an hour from start to finish, and attained the unprecedented maximum speed of 130½ miles an hour. The chief significance of this performance lies in the fact that it was achieved by the use of alternating-current motors, for it cannot be denied that the event foreshadows the use, for high-speed, long-distance travel, of the modern system in place of our low-pressure, direct-current methods. Another fact of great importance during the year has been the placing in service upon a suburban line in Berlin of a trolley car driven by a new single-phase, alternating-current motor which takes its current at 6,000 volts direct from the line to the motor without the use of transformers or converters. If no unforeseen difficulties develop this should prove to be the motor of the future, and especially valuable will it be for long-distance travel. During the year both the promise and performance of the much-talked-of electrifying of steam railroads have made a decided advance. One large steam railroad, the North-Eastern in England, has completed an extensive electric equipment of some 40 miles of its suburban roads, and the cars are running. The New York Central Railroad has drawn up complete plans for electric traction on its suburban service in New York city, and the contracts for a considerable portion of this work have been let. The trains will be hauled by electric locomotives of 85 tons weight, two of these being coupled up for hauling the heavier trains. The specifications require that the two locomotives shall be together capable of hauling a 500-ton train at an average speed of 60 miles an hour. Referring again to the Berlin-Zossen trials, it must be understood that while they prove these high speeds to be mechanically practical, there is no suggestion that they are commercially so. It took 1,600 horse power to drive this single car at 130½ miles per hour. The same horse power in a steam locomotive will haul a whole train of cars at 60 miles per hour. The atmosphere presents the greatest source of resistance at this high speed, and the bulk of the work of overcoming it falls upon the first car. However, in a train of cars identical with the Berlin-Zossen car, the horse power necessary for each car would be only a fraction of that necessary for a single car in running at the speed attained. We shall probably see a high-speed road installed and running within the next few years.

AERIAL NAVIGATION.

It is a curious anomaly to have to admit that while science and nature alike point to the aeroplane as the proper type of machine for mechanical flight, the practical results of the year, with one exception, point with equal emphasis to the cumbersome dirigible balloon as affording, for the present at least, the only solution of the problem. While Spencer, Santos-Dumont, and Lebaudy are navigating the air with a degree of certainty and security that compels one to an increasing belief in the possibilities of the balloon, Langley's aerodrome scorns its native element, and dives incontinently into the waters of the Potomac. As an offset to the failure of the aerodrome is to be recorded the successful flight of a motor-driven aeroplane built by the brothers Orville and Wilbur Wright—an event of supreme importance in the history of aeronautics, inasmuch as it is the first case of an aeroplane, carrying its own engine and an operator, making a trip over several miles of distance. The machine, which has a surface of 510 square feet and is driven by a 16-horsepower motor, is stated to have carried Mr. Wright for a distance of 3 miles against a 20-mile-an-hour wind at a speed of about 8 miles an hour—an actual speed of nearly 30 miles an hour through the air. This feat marks the commencement of an epoch in the history of the aeroplane; for now that an aeroplane has been built that can fly, the work of gathering experimental data will proceed with a rapidity which was impossible when aeroplane flight, at least on a full-sized scale, had never gone beyond the theoretical stage.

The event of the year in the development of the balloon airship, on the other hand, was the successful flight of the Lebaudy airship, when the two brothers traversed the 46 miles from Moisson to Paris in one hour and forty-one minutes, a speed of about twenty-two miles an hour. The significance of this performance lies in the fact that, though the wind was blowing diagonally across the course, the aeronauts had sufficient control of the machine to make the desired point. Comparing the aeroplane with the airship, the problem in the balloon type is to provide sufficient horse power to overcome the enormous atmospheric resistance due to the huge bulk of the balloon. In the aeroplane the chief problem is one of balance and control, and a great step will have been made toward successful flight when some method of control, semi-automatic in action, has been devised, by which a machine can at all times maintain itself in perfect balance, adjusting itself to the varying currents with something of the instinct of a bird on the wing.

CIVIL ENGINEERING.

In the field of civil engineering the most notable event of the year was the opening of the new East River Bridge at New York, which has the distinction of being the longest suspension bridge in the world, and the heaviest, and of providing a width and capacity of roadway which is so great that the structure stands in a class by itself. The next event of importance is the series of political changes at Panama, by which the last difficulties have been removed to the construction of a canal across the Isthmus. The inauguration of another great engineering work was assured by the overwhelming vote by which the people of this State recently declared in favor of the construction of the enlarged Erie Canal. Of the great Croton dam, all that can be said for the year's progress is that the engineers have been engaged in carrying out important modifications which the Merchants' Association, with well-intentioned but misdirected zeal, is endeavoring to prove to be altogether unnecessary. The important Spier Falls dam and power plant has been carried practically to completion during the year, and the Wachusetts dam for the water supply of Boston, the largest reservoir of its kind in the world, with double the capacity of the new Croton dam, has made good progress. The close of the year finds the Pennsylvania Railroad Company's great project for a $50,000,000 system of tunnels and terminal station in this city advanced to the point where the bids for construction are in the company's hands; while the Rapid Transit Subway, in spite of serious delays, is so far ahead of the contract time, that the greater part of the road will be open for traffic early in the spring of this year. We venture to say that, in spite of the widespread attention that has been attracted to the Subway, the public, even in the city itself, have never quite appreciated what a splendid addition it will make to the transportation facilities of New York. In addition to a rapid and frequent local service, there will be a two-minute service, during rush hours, of eight-car express passenger trains, which will run at an average speed of between 30 and 40 miles an hour including stops, over tracks that will be as heavy and well-ballasted as those of any of our first-class steam railroads. It will be possible for business men to travel from City Hall to 42d Street in six minutes, and from the City Hall Park to the Harlem River in a little over a quarter of an hour. Toward the close of the year the Metropolitan Street Railway Company announced its intention, if it could get the necessary permission, of building two subway lines of its own, one beneath Second, and the other beneath Eighth Avenue in this city. The extension of the Subway to Brooklyn is making good progress, and the work bids fair to be finished within contract time. Other notable engineering works that can be merely mentioned are the Philadelphia filtration plant, the completion of the Buffalo harbor breakwater, the completion of the substructure of the Blackwell's Island Bridge, the important improvements of the Ohio River, the work upon the old Hudson River tunnel, one of the tubes being now driven to within a few hundred feet of the Manhattan shore, the successful prosecution of work on the great Simplon tunnel, 10½ miles out of the total of 14 being completed.

WIRELESS TELEGRAPHY.

The record of the year in wireless telegraphy looks barren in comparison with that of the two or three years that immediately preceded it. Experimentalists in this field have been rather finding out what they cannot do than what they can do. We refer to the widespread attention which has been given to the question of tuning or syntony—the development of some means by which the messages between any two or more stations may be receivable by those stations alone. As soon as the idea of utilizing wireless telegraphy for commercial purposes was suggested, it was recognized that some method of secrecy, some system of syntonic safeguard, must be devised before the public would leave the submarine cable for the aerial telegraph. It must be admitted that the most significant fact of the year is the complete way in which the various attempts at syntony have failed. Rival companies seem to have no difficulty whatever in completely disorganizing each others' service, and, indeed, it must be admitted that many of the antagonistic interests have devoted more time and money to destructive tactics than they have to the development of the art of wireless telegraphy itself. It is to be regretted that there is such a complete lack of harmony in the prosecution of this wonderful discovery. Many separate devices of great utility are receiving no practical application whatever, simply because of the unfortunate jealousy of rivals and the determination of each company to work out its own system from Alpha to Omega. An attempt was made during the year to supply news by wireless telegraphy from the United States to the London Times, and a few wireless telegrams were printed. The service, however, was soon discontinued for the alleged reason that important improvements were being carried out at the Marconi station. Among the new systems that have been made public is that of Lodge and Muirhead, who have produced a receiver which consists of a little steel disk which rotates on a globule of mercury that is covered with a fine film of oil. Another device is the Cooper Hewitt interrupter, an outcome of his well-known mercury vapor light experiments. Wireless telegraphy has taken its place as one of the useful inventions of the day. It has a recognized sphere in the merchant marine and the navy, where it has been doing some excellent work. That it will very seriously rival the submarine cable is unlikely, unless, indeed, some more robust apparatus can be devised and some reliable system of syntony developed.

THE AUTOMOBILE.

At the present stage of its development it is probable that the mere mention of the automobile suggests more than anything else to the popular mind the truly astonishing speeds with which it has been credited during the year. And yet the speed of the automobile is, or should be, of but secondary importance in making a review of the year's progress. The most encouraging feature just now is the fact that for the ordinary give-and-take of every-day travel on the roads at normal speeds, the automobile is showing great reliability, while the power of endurance developed under the more exacting conditions of travel is full of promise for the future. Another mark of progress is the great hold which the automobile is obtaining upon public favor. It is a repetition of the history of the bicycle. First prejudice, then toleration, and lastly unqualified approval. No one supposes, however, that the automobile is by any means such a perfected machine as the bicycle. There are several points upon which the attention of manufacturers is still centered in the endeavor to eradicate serious defects; and chief among these should be mentioned the speed gear, in which, on the majority of machines to-day, there is still room for decided improvement. Automobile racing and endurance runs continue to hold the popular interest. The most notable and certainly the most tragic event of its kind was the abortive Paris-Madrid race, which was called off at Bordeaux, because of the frightful fatalities and accidents to the contestants. The winning machine from Paris to Bordeaux maintained an average speed of 63.43 miles an hour, which is about the average speed of the celebrated Empire State Express in this country. Later, in the James Gordon Bennett International Cup Races in Ireland, where the conditions were less favorable to speed, the winner maintained an average rate of 56¼ miles an hour. The world's record for speed for a short distance was broken in Ireland soon after the cup race, in a series of trials in Phœnix Park, Dublin, when Baron de Forrest covered a kilometer at the speed of 86½ miles per hour. This is only 3½ miles per hour less than the highest officially-timed speed for a mile on steam railroads. Perhaps the most gratifying event in the annals of the American automobile during the year was the good behavior of American-built cars in the extraordinarily severe 800-mile contest from New York to Pittsburg, during the fall of the year. The weather was more or less unsatisfactory throughout the whole trip and was about as bad as could be conceived for two whole days. The extraordinary rainstorm of October 18 and 19, which caused a total precipitation of 10 inches, turned the roads into rivers of mud and water, through which the cars plowed as best they could, the majority of them making headway with considerable difficulty only by the continuous use of the low-speed gear. In spite of the severity of the contest, out of the thirty-four machines which started, twenty succeeded in reaching Pittsburg on the same day, and five more concluded the run, making a total of 73½ per cent of the contestants who succeeded in getting their cars through. No test of this severity has ever been made before, and the results bear encouraging testimony as to the good workmanship and design of the average American automobile of to-day.

NAVAL AND MILITARY.

The past year has not been in any sense a notable one in the development of naval and military material. We note the continued tendency to increase of size in battleships and cruisers, the latest designs for British battleships calling for a total displacement of 18,000 tons, although it is now rumored that the new ships are not to exceed the "King Edward" class in size, which means, if it be true, that their displacement will be about 16,500 tons. The largest ships in the United States navy are the five battleships of the "Connecticut" class, which will have a maximum displacement of 16,000 tons and a speed of 18 knots. These vessels will carry the heaviest armament of any battleship afloat. It will consist of four 12-inch, eight 8-inch, and twelve 7-inch, long-caliber, breech-loading rifles, and twenty 3-inch rapid-fire guns, besides thirty smaller automatic and machine guns. The particulars of the two 13,000-ton battleships have been determined upon. They are to be of 3,000 tons less displacement, and one knot less speed than the "Connecticut" class, and they will be armed with four 12-inch, eight 8-inch, eight 7-inch, twelve 3-inch, and twenty smaller guns. They will thus carry four less 7-inch guns and will have one knot less speed than the "Connecticut." But to our thinking they will have an important advantage in the fact that they will carry the submerged torpedo, the omission of which from the "Connecticut" class we cannot but regard as a very serious error of judgment. Our latest type of armored cruiser is represented by the splendid vessels of the "Tennessee" class. These ships will be 502 feet in length, and will have a speed of 22 knots an hour. They will carry the tremendous battery, for a cruiser, of four 10-inch and sixteen 6-inch guns, and a protection of 5 inches on the belt, 9 to 5 inches on the turrets, and 7 to 4 inches on the barbettes. They will thus have the offensive power of the battleship, and will belong to that intermediate class between battleship and armored cruisers which is becoming increasingly popular among the navies of the world. Naval and military ordnance still continues to give most excellent results, the new smokeless powder, in particular, showing satisfactory stability and the guns presenting but little signs of erosion, that *bete noir* of the modern artillerist. An event of considerable interest was the official test early in the year of the great 16-inch 130-ton coast-defense gun, which was built at the Watervliet Arsenal. A projectile weighing 2,400 pounds was fired with a muzzle velocity of 2,306 feet per second, and a muzzle energy of 88,000 foot-tons. The army smokeless powder, which contains about 25 per cent of nitroglycerine, showed no erratic action, even in the enormous charge of 640 pounds, which was used to obtain the velocity above mentioned. This gun is the heaviest and most powerful weapon ever built, the nearest to it in weight being the Armstrong guns of 16¼-inch bore, carried on the British battleships "Benbow" and "Sanspareil," which have shown a muzzle energy of between 54,000 and 55,000 foot-tons; while the next gun to our 16-inch gun in power is the Krupp 12-inch rifle, which with a velocity of 3,330 feet per second has a total energy of about 60,000 foot-tons. The tendency in ordnance is toward larger powder charges, greater length of bore, and higher velocities; and it is quite likely that the next pattern of navy gun will have a service velocity of 3,500 feet per second.

Our own experience with the submarine has not been such as to justify the great expectations which have been held in some quarters regarding the range of usefulness of this type of craft, and the opinion of our army and navy experts, based upon the submarines of the Holland type, is that there is every indication that the submarine will have a limited range of action, and will be confined chiefly to harbor defense. In any case, in its present stage of development its effect will be more of a moral than a practical character, and its work will be strictly defensive. The same opinion seems to prevail in the British service, where extensive maneuvers are being carried on with a few submarines of the Holland type, built by the Vickers-Maxim firm. On the other hand, French naval officers, who have had an extended experience with the submarine, speak in high terms both of its offensive and defensive qualities. Early in the year, the French government published the reports of the various French commanders who participated in the submarine boat maneuvers off Cherbourg; and there seems to be a consensus of opinion among them that it will be possible for the French submarines to leave their stations, and menace any hostile squadron that may be at moorings anywhere within the radius of action of the submarines; that watches on board ship will be of no avail, and that artillery fire will be ineffective. They consider that to insure absolute safety to a squadron anchored within the harbor, it will be necessary to protect the entrance by a system of electric wiring and contacts. But even the French do not speak with enthusiasm of the availability of the submarine for outside work on the high seas.

MISCELLANEOUS.

In drawing to the close of this necessarily brief review of the scientific and engineering events of the year, we cannot but realize how much has been passed by for want of greater space. We would fain speak in detail of the remarkable electro-chemical work being done at Niagara Falls in reducing nitrogen from the atmosphere and in combining new materials for use in the industrial arts; of the discovery of a process for the artificial production of camphor—a method which will, in a measure, render us independent of the Formosa camphor monopoly; of Cooper Hewitt's static converter (an outcome of his brilliant experiments with the mercury-vapor tubes), by which a small glass bulb will take the place of the bulky and expensive static converters, which form so costly an element in our system of electric power and light production and distribution; of the experiments made during the year in electrical canal haulage, which have been so successful as to render it likely that in the near future the trolley will take the place of the mule on the towpath; of that beautiful invention, the telegraphone; of Ruhmer's work in light telephony, and his successful attempt to talk across a beam o[illegible] light for a distance of 4¼ miles. These achievement[illegible] and many another that we have not chronicled, co[illegible] bine with the brilliant discoveries in the world[illegible] chemical physics with which we opened the pr[illegible] article, to render the year that has just drawn[illegible] close one of the most fruitful in the history [illegible] scientific world.