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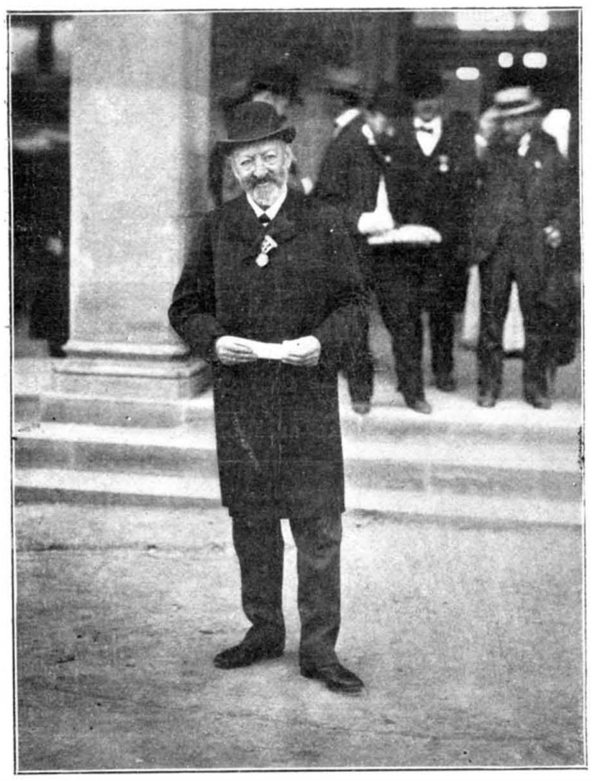
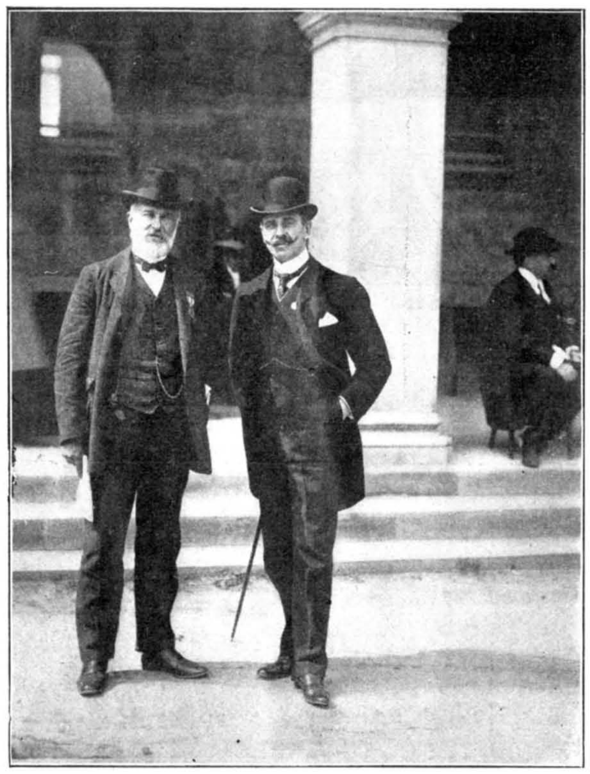
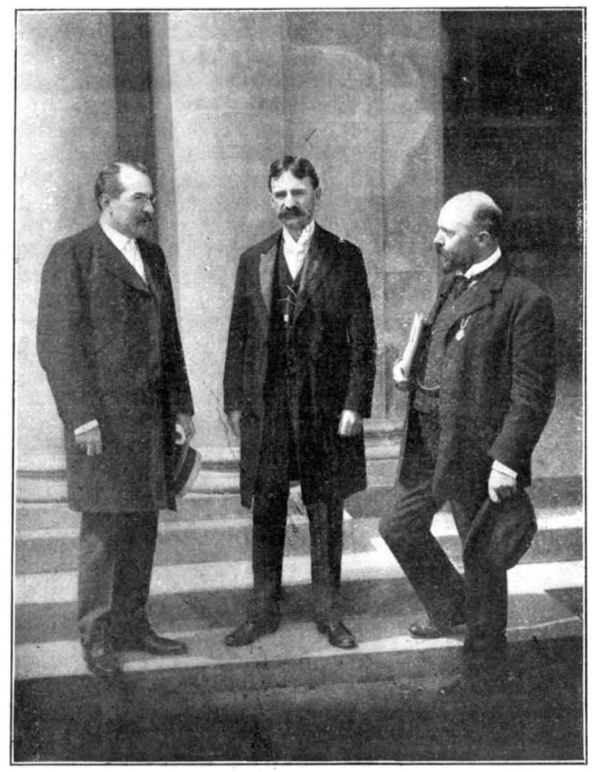


Plant Physiology.—Prof. Julius Weisner, of the University of Vienna.



Department of Constitutional Law.—Attilio Brunialti, Councilor of State, Chevalier Zeggro, of Italy.



Department of Mathematics.—Prof. Emile Picard, Paris; Profs. Heinrich Maschke, of Chicago, and E. H. Moore, of Chicago.

Front Row, Left to Right Prof. I. C. Russell, of Michigan; Dr. H. R. Mill, Director of the British Rainfall Organization, London; Dr. McCormick; Prof. Oldham; Dr. Robert Bell; J. America Dos Santos.

Second Row—Dr. Wilson; Prof. Oberhummer, Vienna; Prof. Georges Blandel, France; Prof. Penck, Vienna; Prof. Bloche, Vienna; M. Martornne, France; Miss Z. Baber, of Chicago; Major Gibbon, England.

DISTINGUISHED VISITORS TO THE EIGHTH INTERNATIONAL GEOGRAPHIC CONGRESS.

THE EIGHTH INTERNATIONAL GEOGRAPHIC CONGRESS—NEW YORK SESSIONS.*

The Eighth International Geographic Congress assembled in the United States from September 8 to October 7. This was the first of its conventions to take place in the Americas, and the occasion was one of great importance to the science in this country. The officers of the congress were: Honorary president, Theodore Roosevelt; president, Commander R. E. Peary, U. S. N.; general secretary, Henry Gannett; treasurer, J. J. Edson. The national interest in the convention is indicated by the fact that the invitation upon which the congress came was extended in the name of all the leading geographical societies from the Atlantic to the Pacific slope. The meeting was peculiar in being peripatetic in character. Business sessions for the reading of papers were held in Washington, New York, Chicago, and St. Louis, while the geography of the country was studied at close range in excursions at Philadelphia, on the Hudson, and to the Grand Canyon of the Colorado and Mexico.

Nearly 200 papers were offered for reading at the Congress, more than one-half of which were scheduled for delivery at the New York sessions. For the sake of classification and for convenience in reading of the papers, the Congress was divided into twenty sections and subsections, nine of which contained the papers read in this city. It will be impossible in the limited space which can be allotted to a report of the proceedings of the Congress to do more than outline some of the generally interesting papers. A large proportion of the papers on the printed programme was read by title only for one reason or another. The "Compte Rendu" of the Congress will contain all the communications in full, and will appear in about a year.

date in equipment for the carrying on of all kinds of investigation of the ocean. Dr. E. O. Hovey, of New York city, gave the geographic results of the expeditions to the West Indies sent by the American Museum of Natural History directly after the eruptions of 1902-1903 began. The author showed by means of lantern slides the changes due to the eruptions and particularly the formation of the spine of Mont Pelé by lava forced up in a state of viscosity too great to permit flowage. The cone of Guadeloupe has been formed in the same way as the spine of Pelé.

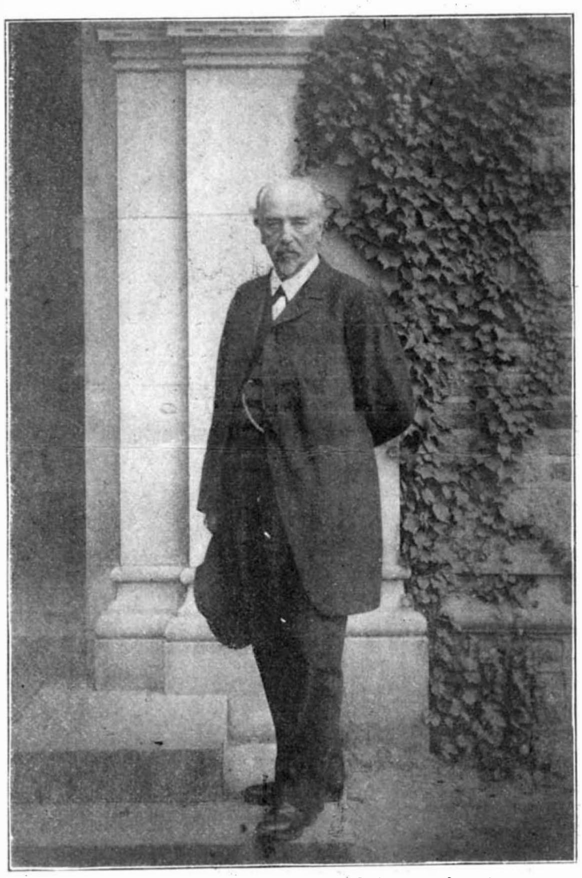
General interest centered in the joint popular lecture Tuesday evening, at the Natural History Museum by Dr. and Mrs. W. H. Workman, of Worcester, Mass., who gave a *résumé* of observations and the narrative of their recent expedition into the high Himalayas. On this expedition Dr. Workman established a new record for land ascents, reaching an altitude of 23,397 feet above the sea, while Mrs. Workman climbed within a thousand feet as high, the greatest altitude yet attained by a woman. The lecture was illustrated with a profusion of admirable lantern slides of the peaks, snowfields, glaciers, and moraines of the region traversed by the explorers. The lecture was followed by a reception at the house of the Geographic Society.

A banquet, complimentary to the foreign delegates, was held at the Endicott Hotel Wednesday evening, and was the occasion of speeches by the representatives of several foreign governments and societies. In the course of the evening Prof. Henri Cordier, with a laudatory address, presented to Commander Peary the gold medal which had been awarded to him by the Geographic Society of Paris on account of the value of his discoveries in Arctic regions. At the close of the banquet Commander Peary announced that his plans for a new attempt to reach the North

the Antarctic regions. He outlined a plan for the establishment of at least twelve stations for the making of simultaneous observations for not less than one year at widely separated points on the still very imperfectly known atmospheric conditions of the Far South. The entire expense of the undertaking is estimated at about $530,000, and the results would be of great and permanent value. Dr. Cook detailed some of the results of the voyage of the "Belgica," dwelling upon the importance of the records obtained thus for the first time of a complete yearly cycle in the Antarctic.

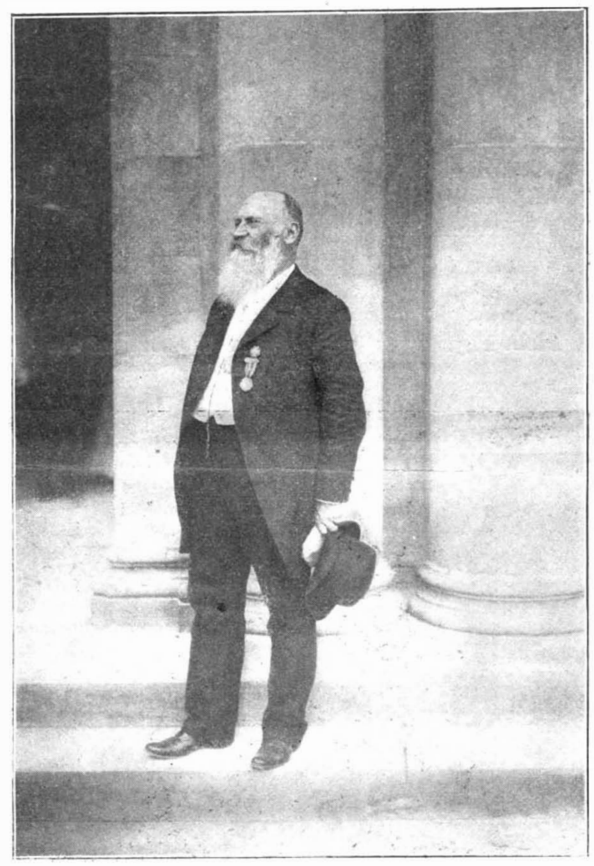
Prof. Thoulet, of Nancy, reported upon the progress which had been made toward the production of the general chart of the depths of the ocean which has been undertaken by the Prince of Monaco, inspired by the indorsement given the project by the Berlin Congress of 1899. The work is under the immediate care of Profs. Thoulet and Sauerwein. The chart will be issued on the scale of 1-10,000,000, in twenty-four sheets. The meridian of Greenwich has been chosen as the standard, isobaths will be expressed in meters, and the terminology will be the international form adopted by the Congress committee. Prof. Thoulet showed the oceanographic charts which he has prepared of the Azores. The several charts show the isobaths, the thermal contours at sea bottom and at a depth of 1,000 meters, the distribution of lime and of ammonia in the submarine soil.

Prof. R. T. Hill, of Washington, in a paper on the physical geography of Mexico, said in part that the country is divided into four distinct geographic provinces, which are: The Sonoran, the Plateau or Chihuahuan Province, the Gulf Coast Plain, and the Isthmian Province. Of these the Plateau Province embraces nine-tenths the area of the republic, and



Prof. Benno Erdmann, Methodology of Science. University of Bonn.

Prof. K. Mitsukuri, University of Tokio, Japan. Oceanography Department.



Prof. Wilhelm Waldeyer, Human Anatomy. University of Berlin.

DISTINGUISHED VISITORS TO THE EIGHTH INTERNATIONAL GEOGRAPHIC CONGRESS.

At the introductory general session held at the house of the American Geographical Society, general papers were read by delegates from England, Germany, France, and the United States. Sir John Murray, of H. M. S. "Challenger" fame, discussed deep-sea explorations throughout the world and stated as one of his conclusions that continued investigation strengthened the theory of the permanency of continental and oceanic areas as such. The oceanic basins are the stable part of the earth's crust; the continental areas have been the unstable parts. Count Joachim von Pfeil, of Lauban, Saxony, in speaking on "The rise and development of the German colonial possessions," said in part that many of the present German possessions were acquired without the consent of the government at Berlin. In 1884 the speaker, Dr. Juhlke, and Dr. C. Peters took steerage passage to Zanzibar, *en route* to what is now known as German East Africa. The steerage passage was taken for the purpose of concealing the object of the expedition from England and other European powers. These three private citizens explored the new region, gained the friendship of the native chiefs, and then persuaded the Berlin government to enter into treaties which secured vast areas to Germany and led to the establishment of important colonies. In the absence of the author Prof. J. Thoulet, of Nancy, France, read a paper by the Prince of Monaco regarding the studies of the ocean which have been carried on for twenty years by the prince and at his expense. The work began in 1885 with a sailing yacht of 200 tons, which was replaced in six years by a steam yacht of 600 tons. which in turn gave way in 1897 to a steam yacht of 1,420 tons. Each vessel has been thoroughly up-to-

* Specially prepared for the Scientific American Supplement

Pole had advanced so far that the contract for the new ship needed for the enterprise had been signed. The ship is to be of a model calculated to crush thick ice in her path, and her engines are to be capable of developing 1,500 horse-power for short periods and 1,000 horse-power continuously. Sail power is to be reduced to a minimum, and will be used only for creeping home in case of complete breakdown of the engines. Eskimos alone are to comprise Peary's party in his final dash for the pole. The start from New York will be made next summer.

In the sections the papers were so numerous and the interests discussed so varied that it is impracticable to do more than hint at the communications submitted. Dr. F. A. Cook, of Brooklyn, made a comparison of the Arctic and Antarctic regions as fields of exploration from his personal observations. The Arctic is the more interesting and inspiring on account of better climate, more cheerful colors and the life which extends to higher latitudes. More romance has attached to the north, where the object has been the attainment of the pole, than to the south, where the object has been the delimitation of the polar continent.

Mr. R. A. Harris, of Washington, gave a paper on the "Evidence of land near the North Pole," in which he detailed results based upon studies of tides, currents, etc. The main conclusion arrived at was that a large tract of land may extend from near the North Pole toward Alaska and eastern Siberia—one corner lying nearly north of Bennett Island; another, a little west of north from Point Barrow; a third, a comparatively short distance northwest of Banks Land; and a fourth corner north of Lincoln Sea.

Dr. Henry K. Arctowski, of Brussels, made a strong appeal for united effort among nations for research in

is its chief physical feature, to which the other provinces are subordinate. The Plateau Province is shown to be the southern continuation and end of the great North American Cordilleran system. Its relations, however, are not with the Pacific Mountains or the Rocky Mountain ranges, but with the Colorado Plateau. This plateau in Mexico is surrounded by fringed escarpments, in the erosion and faulting of which is recorded its physiographic history. The eastern scarp is the edge of the anticlinorium of folded strata constituting the mass of the Plateau. The western edge is the vast fault scarp now receding to the eastward by erosion, upon the downthrown side of which is the Sonoran, or Pacific Province. The southern end of the Plateau abruptly terminates at the Pacific Ocean, and is probably caused by faulting accompanying the east-west strikes of the later orogenic history of the Antillean region, which here directly crosses the northwest-southeast strikes of the Cordilleran system. The great volcanoes of Mexico rise on the edge of this plateau.

Prof. John N. MacGonigle described the Everglades of Florida, saying that they consisted of a great rock basin of Vicksburg (Tertiary) limestone with a water-worn rim. No water runs into the Everglades but a great quantity runs out. The region is characterized by great springs of fresh water and underground streams. The water has a general movement from north to south. The sources of the water are the heavy rains from June to September and the subterranean rivers.

Prof. Herschell C. Parker, of Columbia University, described the first ascents, which were made by him, of Mounts Lefroy, Dawson, Goodsir, Hungabee, Deltaform, and Biddle. Some of these peaks of the Canadian Rockies present some of the greatest difficulties

met with yet in Alpine work in America. The ascents were made in 1897, 1899, and 1903. Dr. F. A. Cook gave the results of a reconnoitering journey around Mount McKinley made by him in 1903. This mountain is the culminating peak of North America, rising to an altitude of 20,350 feet. On every side Mount McKinley is a succession of granite cliffs and overhanging glaciers. It is remarkable not only for its great height, but also for being the steepest, the most Arctic, and possibly the most picturesque of the great mountains of the world.

Prof. Robert T. Hill, of Washington, in a paper on "The larger story of Mont Pelé," gave some of the results of his extended observations in the West Indies and his studies of the Martinique eruptions. He emphasized the idea that the recent eruptions are minor incidents in the geologic history of the islands, which have been built up from the sea-bottom by successive eruptions. Soundings show that there are three submarine projections extending northward from the South American continent. The Lesser Antilles are not to be regarded as the tops of a mountain range which has been drowned by subsidence. Prof. Angelo Heilprin, of Philadelphia, discussed "The Tower of Pelé," illustrating his remarks with lantern slides from photographs taken by himself. The speaker dissented from the generally accepted view that this obelisk or tower represented rapidly-cooling lava, the solidification of which was effected at the time of extension. He expressed his belief that the tower was an ancient volcanic core, or plug, which had been dislodged and lifted out by the volcanic forces. In another paper Prof. Heilprin presented his views on the destruction of Pompeii by Vesuvius in A. D. 79, which are that the city was not destroyed as the result of simple incineration, as is generally assumed by geologists and others, but that the havoc was wrought like the annihilation of St. Pierre, Martinique, by an exploding cloud of dust-laden steam which rolled down the mountain.

Prof. Dr. A. Schmidt, of Stuttgart, Germany, detailed the results of observations on earth vibrations which he has made with the trifilargravimeter, a very delicate instrument, recently devised. The earth's crust is found to be transmitting waves which have not been suspected heretofore. These waves are long between crests, four to five minutes elapsing between maxima, and are six to seven inches in height. These remarkable indications are being studied with care.

In the section of economic geography the papers presented were of timely interest and value. Prof. E. R. Johnson, of Philadelphia, discussed governmental influence upon the geographical distribution of commerce, showing the influence of natural as opposed to artificial considerations in determining trade routes. Prof. A. de Claparède, of Geneva, Switzerland, spoke of the economic value of Switzerland, due to her mountains being the collecting ground for many important rivers. The geographic development of the internal commerce of the United States was the topic dwelt upon by Dr. J. F. Crowell, of Washington, who showed how the great natural highway of commerce, the rivers and lakes, had affected the trend of trade in the interior of the continent. In a paper upon "The economic importance of the plateaus in tropic America," Prof. J. R. Smith, of Philadelphia, called attention to the fact that tropic America presents the unusual spectacle of a region in which one type of district supports most of the population, while another supports the more important foreign trade. The majority of the people live upon the poorest land, the plateaux, in positions very difficult of access to commerce, while the fertile and accessible lowland regions along the coast are unsettled. The lowlands are the real tropics of commerce, and the question is, Can they be peopled and developed? Two solutions of the problem have been offered: The importation of Asiatic coolies and the scientific treatment of the region to make it habitable by Caucasians. The first method is being successfully tried in some countries, and the second is full of possibilities.

Dr. T. W. Thorndike, of Boston, called attention to the economic importance of the vast swampy "Muskeg region" lying southward of Hudson Bay and the Canadian Barren Lands. Its value lies in its being the natural breeding ground for many fur-bearing animals —the setting aside of the area as a government preserve for the propagation and protection of the game and fur-bearing animals. Such action furthermore would probably result in the settlement of the Indian question for Canada, the Indians being by nature hunters and trappers.

In a paper on "The relations of commerce to geography" Mr. O. P. Austin, of Washington, showed how commerce and exploration had almost always gone hand in hand. An instance of this is the fact that the search for a route to India led to the discovery of America and southern Africa. The great commercial and geographical work of the twentieth century should and will be to make the great area lying between the thirtieth parallels of north and south latitude contribute its proper share to the requirements of man. This vast zone contains one-half the land area of the globe and one-half the population, but at present it contributes only one-sixth of what enters into international commerce.

Geographical science has lately been making rapid strides in Hungary, as was shown in a paper by Dr. B. Erödi, of Buda-Pest, who said in part that it was only recently that the country had displayed any considerable methodical activity in this field of study. Geographic, geologic, and ethnologic societies have been founded under royal patronage, and several governmental departments carry on systematic work along geographic lines. In the popularization of the science much is due to the Urania Theater of Science, which has been working for several years and has produced more than one hundred geographic pieces dealing with Hungary and foreign countries. The papers dealing with the educational side of geographic science were rather more technical in character than those which have been cited. The papers on anthropogeography were reserved for reading at St. Louis, where the Congress met in conjunction with the International Congress of Arts and Sciences of the Exposition. One hundred and twenty delegates from foreign countries and societies attended the Congress, and the total registration of attendants was between seven and eight hundred. More than one hundred participated in the excursion to Niagara Falls and Chicago, while seventy-five went to the Grand Canyon and Mexico. The next session of the Congress will be held in Geneva, Switzerland, in 1908.

CONTEMPORARY ELECTRICAL SCIENCE.*

Propagation of N-Rays Along Nerves.—A. Charpentier has found that it is possible, by means of the N-rays, to map out the nervous system of the living subject. If a small fluorescent screen is held in the hand, or placed on the tips of the fingers, its luminosity is increased if any other part of the skin is touched with a portable source of N-rays or with the end of a wire conducting N-rays. The increase of luminosity varies according to the more or less close nerve connection existing between the fingers and the point touched. Thus it is great when the trunk nerve of the arm is touched. The nerve may thus be followed right up to the brain, and it is found that in the brain itself the sides are changed, and the centers on the side opposite the fingers must be touched in order to produce a sensible effect. This is quite in accordance with the general laws of innervation. The author points out that a similar mapping out of the nervous system may be carried out by means of faradization, but that procedure is painful, whereas the N-rays are not felt. A screen placed over the heart shines out when the N-rays are applied to the neck where the pneumogastric nerve crosses, or better still, to the inferior cervical and superior dorsal regions of the medulla. Another effect recorded is the transmission of N-ray effects from one side to the symmetrical point on the opposite side.—A. Charpentier, Comptes Rendus, March 14, 1904.

New Carbide Process.—Carbon only reduces the oxide of calcium at a temperature at which the latter becomes liquid. The manufacture of calcium carbide, therefore, requires an enormously high temperature and an electric furnace to produce it. It is pointed out, however, by H. Moissan, that metallic calcium combines with lampblack to produce calcium carbide at any temperature above red heat. In any electrolytic process, therefore, where calcium is produced in contact with carbon at a red heat, calcium carbide is formed. The author bases a new carbide process on these considerations, which, however, appears not to have any commercial value, since the carbide obtained is firmly embedded in a fused mass of calcium chloride and fluoride. A graphite crucible, which serves as the positive pole, is filled with calcium chloride fused by means of a small electric arc. A vertical rod of graphite serves as a negative electrode. The chloride is put in gradually, and after the first fusion electrolysis is carried out by means of a current of 10 to 15 amperes at 120 volts. Chlorine is given off freely, and after an hour the process is stopped and the crucible broken. Under the crust is found a mass with a crystalline fracture. The central portion dissolves in water, and evolves a mixture of gases containing some 14 per cent of acetylene, the rest being hydrogen. The process is greatly improved by mixing the chloride with a quarter of its weight of fluoride, which makes the fused mass more fluid and the conduction of the current more regular. The amount of carbide obtained is small, but it may be increased by adding to the liquid a coarsely-powdered mass of petroleum coke.—H. Moissan, Comptes Rendus, March 14, 1904.

Sensitizing Tissues for the Light Cure.—The physiological and bacteriological action of light increases from the red end to the blue end of the visible spectrum. The penetration of light, on the other hand, increases from blue end to the red end. This means that the most active rays are the least able to penetrate any but the most superficial tissues, and the failure of the light cure in deep seated affections is attributable to this fact. S. Leduc has worked out an ingenious plan which promises to get rid of this difficulty. He bases it upon the well-known effect of certain organic coloring matters in sensitizing photographic films for the less refrangible rays of light, and on Dreyer's work on sensitized cultures of bacteria and infusoria. The cultures are sensitized by means of a 1-40th per cent solution of erythrosine, which by itself has no action upon them. The cultures are then exposed to light filtered through various media, such as quartz, glass, nickel sulphate, potassium chromate and potassium bichromate, and the effect noted in each case. The bacteria show no increase of mortality due to the sensitizer when exposed to the whole of the spectrum. But whereas the non-sensitized bacteria would live for nine hours under the action of the red and orange light, they are killed off in 25 minutes in the sensitized culture. The infusoria show an even more pronounced effect, death occurring after 10 seconds, instead of two hours. The penetrating rays thus acquire the same bactericidal efficiency as the violet and ultra-violet rays. The action is due to a real sensitization, and not to an absorption of certain wave-lengths of light. For there are substances which absorb exactly the same waves and produce no corresponding effect. Neither do the results depend upon the production of a toxic substance by the illumination. For, if the illumination takes place independently and the bacteria are then introduced, they do not die off.—S. Leduc, Arch. d'Electr. Méd., March, 1904.

Variable Motion of Electrons.—In a paper on "The Internal Field of the Electrons," E. Kohl investigates mathematically the problem of the non-uniform motion as against the uniform motion of an electron, which has hitherto almost exclusively been dealt with. To do this he has to make very general assumptions, and he goes so far as to attribute a structure to the electron, supposing it to consist of smaller particles rigidly connected. He obtains three integrals for the complete motion of an electron, two of the integrals disappearing when the internal connections are rigid. He finds that in an electron in purely translational motion no couples occur owing to internal forces, and that, therefore, such an electron can only acquire a rotation owing to the action of external forces. Such forces might be brought into play in a highly non-uniform field, and then the electromagnetic energy would no longer be measured by the work of the convection current. The author discusses the question of the apparent mass of electron, and inclines to the conclusion that it is only partly electromagnetic, on the ground of certain phenomena of emanation. That in all known forms of motion of electrons the motion is purely translational may be ascribed to the very small size of the electron, which makes every electric field comparatively uniform.—E. Kohl, Ann. der Physik., No. 4, 1904.

Optical Ammeter.—E. Orlich describes a method of measuring currents which is employed at the Reichsanstalt for testing alternate-current ammeters. It consists in heating to incandescence a sheet of platinum foil by a continuous current and an alternate current in succession. If the effective value of the alternate current equals that of the continuous current, the amount of heat developed in the platinum foil is the same in both cases, and if the emission is also the same, the sheet must attain the same temperature in both cases. The equality of temperature may very conveniently be tested by Holborn and Kurlbaum's optical pyrometer. An image of the glowing platinum is projected by means of a lens upon the filament of a small incandescent lamp, which is observed through a second lens. The current feeding the lamp is so regulated that the filament apparently disappears in the bright background. Special provision has to be made for constancy of temperature. As regards radiation, it is kept constant by allowing the platinum to radiate into the open air, and the conduction of heat is kept constant by perforating the electrodes and supplying them with a stream of cold water. The temperature imparted to the platinum sheets varied from 400 to 1,400 deg. At higher temperatures the method loses in sensitiveness, and the platinum begins to evaporate. The author quotes a number of tests of commercial ammeters. A Kelvin hectoampere balance with sub-divided copper leads gave correct readings, but a kilo-ampere balance containing massive leads required an alternate current 5 per cent stronger than the corresponding direct current to produce the same temperature.—E. Orlich, Zeitschr. für Instrumentenk., March, 1904.

* Compiled by E. E. Fournier d'Albe in the Electrician.

THE SYNTHETICAL MANUFACTURE OF ALCOHOL.

The question of the chemical manufacture of alcohol being of current interest, we have received a large number of requests for information from our subscribers. In response we give an account of the Fournier process. This is regarded as quite practicable, but it is important to have knowledge of the cost price of the alcohol thus obtained.

The synthesis of alcohol was first accomplished by M. Berthelot. The solution that he made was the result of saponifying the acid sulphate of ethyl, after having precipitated this by means of ethylene and sulphuric acid. This solution has not been adopted in industry.

Attempts have also been made to obtain alcohol by synthesis in the laboratories by different circuitous methods. One of them, for example, consists in treating ethyl-iodide with potash, the ethyl-iodide itself proceeding from acetylene. These methods are complicated and costly and cannot be employed in industry.

The Fournier process is based on the direct employment of acetylene without its previous conversion into other intermediate bodies. The formula of alcohol, as known, is C_2H_6O; that of acetylene C_2H_2. To produce alcohol with acetylene it is, therefore, necessary to add to the molecule of this gas four atoms of hydrogen and one of oxygen, but under ordinary conditions the three gases acetylene, hydrogen, and oxygen, cannot be associated for producing alcohol; besides, these gases, mingled together, do not react on each other, except by complete combination, when the temperature is raised. The Fournier process utilizes

the oxidizing property of ozone, but so managing the action of this gas as to obtain alcohol at once, with an increasing yield afterward, and for this purpose to avoid as much as possible the formation of more double inclosure.

The operation is conducted in an elongated receiver of glass or porcelain, the tube serving for the admission of the three gases, acetylene, ozone, and hydrogen, designed to react on each other, being of the same material. It is well that the diameter of the receiver should in no case exceed 20 centimeters in order that the interior surface may be cooled as rapidly as possible. For extensive production a large number of receivers are employed, arranged in a metallic vat, containing iron filings, or a liquor whose point of congelation is below 80 deg. C.; this vat itself is surrounded by thick felt, or wood sawdust, kept in a double inclosure.

Around the receiver in the metallic vat a worm is placed, through which the carbonic acid gas is made to pass under pressure. This is solidified in the worm and produces considerable cold.

The acetylene may proceed from any generator and be accumulated in a gasometer of known volume; the hydrogen and oxygen, the latter to be converted into ozone, may be obtained by the electrolysis of water. The hydrogen and acetylene, previously mingled, pass through a desiccator containing quicklime, and afterward through a filtering apparatus containing asbestos. The oxygen is dried in the same way before reaching the ozone apparatus, which may belong to any system, provided it is sufficiently powerful and secures a good yield.

The operation takes place in the following manner: It commences by cooling the receiver, causing the carbonic acid to penetrate the interior of the worm that surrounds it. The carbonic acid may be solidified in the worm, and when the receiver is sufficiently cooled, the mixture of acetylene and hydrogen, previously determined, may be admitted. The oxygen is admitted in the same way. On account of the cold in the receiver, the alcohol formed is not subject to ulterior chemical reaction, which might change it, and it descends into another receiver, where it is also greatly cooled. In this manufacture of alcohol from acetylene by synthesis, electric energy exercises an important action. Without speaking of its employment for producing calcium carbide in the electric furnace for the production of acetylene, it is electric energy which produces the hydrogen and oxygen by the electrolysis of water and which also yields ozone by afflux of oxygen.—Translated from La Revue des Produits Chimiques.

ARTIFICIAL COTTON IN FRANCE.

The French Chamber of Commerce of Milan says that an artificial cotton is now made from the cellulose of the fir tree freed from bark and knots. The fibers, after being pulverized by a special machine, are placed in a horizontal brass lead-lined cylinder of some 3,500 cubic feet capacity and steamed for ten hours, after which 2,000 cubic feet of a bisulphate of soda wash is added and the whole is heated for thirty-six hours under a pressure of three atmospheres. Then the wood, or fiber, which has become very white, is washed and ground by a series of strong metallic meshes, after which it is again washed and given an electro-chemical bleaching by means of chloride of lime. Passage between two powerful rollers then dries the matter, producing a pure cellulose, which when reheated in a tight metal boiler containing a mixture of chloride of zinc and hydrochloric and nitric acids, to which is added a little castor oil, casein, and gelatine to give resistance to the fiber, gives a very consistent paste. Threads are then produced by passing this paste through a kind of draw-plate. These threads, after being passed over a gummed cloth, are immersed in a weak solution of carbonate of soda and passed between two slowly-turning drying cylinders. Finally, to give the necessary solidity, the thread is treated to an ammoniacal bath and rinsed in cold water, after which the product is pliable and works well.

In Bavaria experiments have recently been made to produce cotton from pinewood, and it is claimed that the trials have been very successful.

ELECTRICAL HEATING APPARATUS OF A NEW TYPE, AND ITS APPLICATION TO THE BAKING OF BREAD.

It would seem as if electric heating was destined in the near future to be utilized and to render important services. Mr. F. Le Roy, who has devoted much attention to this question, has recently devised a new system that appears to us to be worthy of a short description. He became convinced of the fact that for electric heating it is necessary to establish movable and easily changed elements adaptable to all heating apparatus and capable of being used upon the usual electric circuits; that heating apparatus constructed with such independent elements should, in order to be practical, require no other repairs than the changing of the elements; and that these latter themselves should be capable of being repaired by any electrician at a slight expense.

Starting from these principles, Mr. Le Roy constructed a heating element that consists essentially of a porcelain support (Fig. 1) having a screw thread upon which is wound a metallic conductor formed of a special alloy. The two ends of each porcelain are provided with metallic caps forming current collectors, and to which are attached the ends of the wire constituting the electric resistance. The metallic conductor wound around the porcelain is formed of several juxtaposed wires which permit of the use of a greater current density than with a single wire, since the heat-radiating surface is greater than with one. The result is that, in order to form a given resistance, the length of the wires is necessarily less, and there is a saving in the weight of metal. By the passage of the electric current, the wires are raised to a red heat, and the porcelain itself soon becomes incandescent, thus increasing to a large extent the surface of calorific emission. The screw thread and the conductor have been so calculated that the elements may be used upon a 120-volt circuit. M. Le Roy has designed three models of elements (Fig. 1), each of which is made in two types. These three models consist of (1) small elements, which have a length of 5.118 inches and a diameter of 0.787 of an inch, and consume 1 or 1.8 amperes at 120 volts, or 120 and 215 watts; (2) the medium-sized elements, which are 8.661 inches in length and 1.181 inch in diameter, and consume 2.5 amperes at 120 volts (300 watts) or 7.5 amperes at 60 volts (450 watts); and (3) the large-sized elements, which are 11.811 inches in length and 1.968 inches in diameter, consume, at 120 volts, 7 or 8.5 amperes (840 or 1,020 watts).

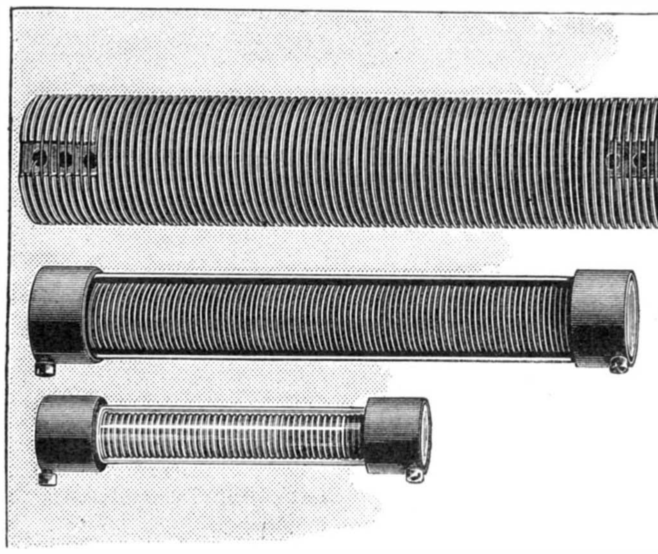


Fig. 1.—LE ROY ELECTRIC HEATING ELEMENTS.

The various heating elements are placed in a jacket consisting of a glass cylinder for stoves and fireplaces, and a half-cylinder of asbestos for domestic apparatus.

The small elements are employed in stores, fireplaces, and domestic apparatus (Fig. 2, No. 2). By combining the elements, it is possible to reach consumptions of 9, 16, and 19 amperes at 120 volts and obtain sufficient heat to properly warm volumes of air of 882.87, 1,553.86, and 1,760.75 cubic feet.

The medium-sized elements are designed for cooking apparatus. By grouping them by fours they form heaters of 1,000 and 1,800 watts consumption, capable of giving several degrees of heat. The small stove with an open front and a broiler (Fig. 2, No. 3) has an 1,800-watt set of elements. The upper part has a lid formed of several rings, by removing which there is exposed a grating directly over a number of elements. A saucepan placed upon it is heated both on the bottom and periphery, and the utilization of the heat is therefore perfect.

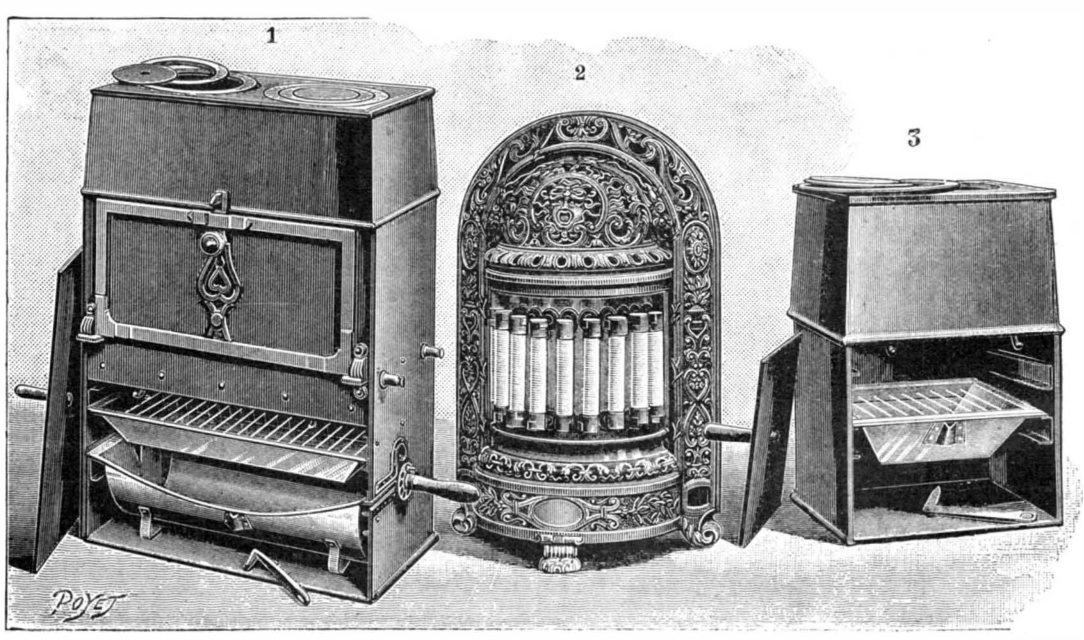


Fig. 2.—ELECTRIC HEATING APPARATUS.

1. Stove with two holes and a roaster and broiler. 2. Parlor stove. 3. Stove with one hole and a broiler.

The large stove (Fig. 2, No. 1) comprises two saucepan holes with heaters of 1,800 watts each, and a roaster and broiler with two independent 1,000-watt heaters. The stove placed between the two is heated by these same sources. The large elements form, in a very limited space, exceedingly powerful sources of heat, and they were employed in bakery ovens in some very interesting experiments made by M. Le Roy at Montauban. The electric heater used consisted of twenty 700-watt elements connected in multiple upon a 110-volt circuit and arranged in four rows—two of 37.5 amperes in the center, and two of 25 amperes at the sides, or a total of 125 amperes. These elements were arranged upon a circular frame (Fig. 3), which a system of pulleys permitted of lowering to the bottom of the oven or of raising against its dome. The electric energy was taken from the 110-volt circuit of the Société Montalbanaise d'Electricité.

At the start, the temperature of the oven was in the vicinity of that at which an oven is usually emptied. The four rows of elements were operated together, consuming 125 amperes at 110 volts, or 13,750 watts. After an hour and a half of operation, that is to say, after a consumption of 20,625 watt-hours, the necessary temperature was reached, and it was possible to begin filling the oven (Fig. 4). The floor of the oven was hot enough to form a crust on the bottom of the loaves immediately. The heater was hoisted to the dome and all its elements were kept in operation only during the fifteen or twenty minutes required for putting 330 pounds of dough into the oven. The successive operation of each row of elements for 15 minutes at a time was all that was necessary for finishing the baking of the bread.

After the 330 pounds of dough has been put in the oven, a total heating of 40 minutes, following two hours and a half of general heating to get the oven to the right temperature, is all that is necessary for baking the bread. The consumption of electric energy in the experiment was 34,375 watt-hours. For fancy bread, the time of heating might be shortened, and the energy consumption be reduced to 25,000 watt-hours. This oven was formerly heated with oak wood, and, for the first baking, 330.69 pounds of oak wood, worth 21 cents a hundredweight, was daily used at a total cost of $0.64, while for the others, 220.46 pounds were employed. The time necessary was three hours per oven, requiring the continual presence of a workman to keep up the fire, remove the ashes, etc. M. Le Roy's experiments at Montauban clearly established the fact that electric heating can be utilized industrially, but that it is twice as expensive as coal or wood fuel.—Translated from La Nature for the Scientific American Supplement.

Furniture-cleaning Polish.—Melt together 4 parts of yellow wax and 1 part of colophony, and add 15 parts of oil of turpentine. The mass may be colored with ocher or umber. Put a little of this mixture on a woolen rag, and rub the furniture with it.—Die Fundgrube.

THE PROBLEM OF THE TELEPHONE RELAY.

By Dr. John Trowbridge.

The future historian of the rise and progress of telegraphy and telephony in America must devote much space to the invention of the telegraphic relay; and to a consideration of the claims of Morse and of Henry. The relay in the early days of telegraphy seemed all-important; but in these days of better electrical engineering it has lost the pre-eminent regard it had among the early telegraphers. Nevertheless, it has its place and important functions. The wonder is that the sister art of telephony has not followed the progress of telegraphy and has not already its relay.

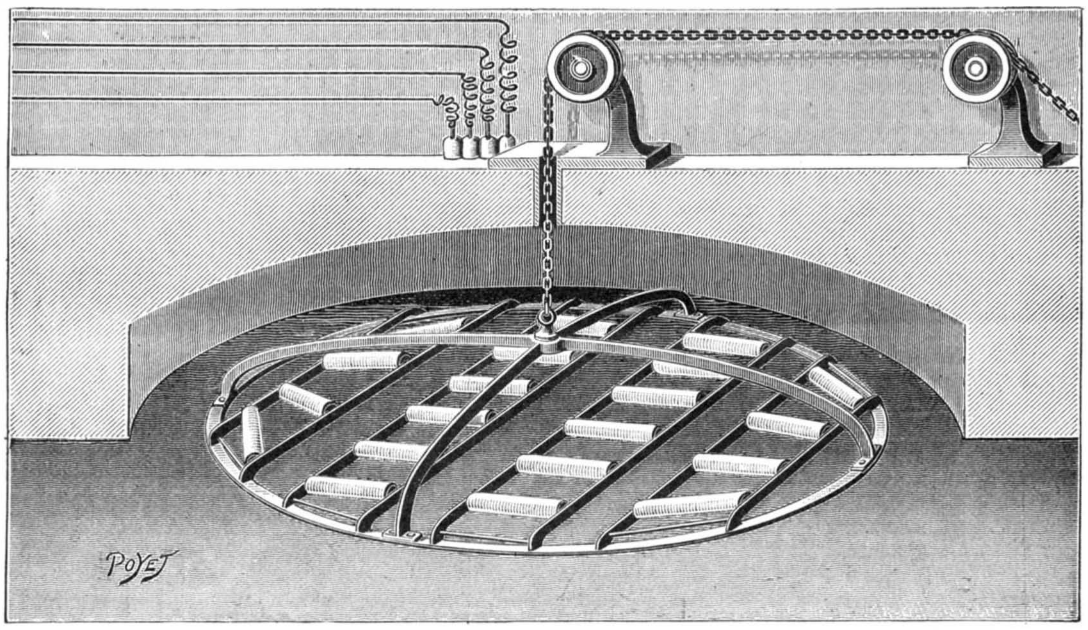


Fig. 3.—GRATE ARRANGED WITH LE ROY ELECTRIC HEATING ELEMENTS IN THE EXPERIMENTS IN HEATING A BAKERY OVEN AT MONTAUBAN.

The tendency of the times is in the direction of improved telephone lines rather than in employing more sensitive instruments on comparatively imperfect lines.

The telephone is generally regarded as a very sensitive instrument even in its practical form; a telephone relay must evidently be more sensitive than the telephone it proposes to relay; many telephone engineers, therefore, doubt whether a relay can be invented, especially when one considers the crepitating and buzzing effects of carbon transmitters. Such engineers, therefore, believe that long-distance telephony must result from improved lines rather than from relay instruments. The cost of such improved lines, however, is enormous and soon becomes prohibitive, and a practical relay is much to be desired from the point of view of economy. From a scientific point of view, it would be of great interest; for the working of such an instrument in transmitting rapid alternations unimpaired or slightly modified, could not fail to increase our knowledge of acoustics. It would also round out the relations of telegraphy and telephony.

I have, therefore, devoted much time to the subject of the telephone relay and have produced an instrument which works on lines of a certain character.

Before speaking of the character of its working, let us consider the problem of the telephone relay more closely. We have said that the telephone is considered a very sensitive instrument. The student of acoustics, however, soon finds that it is a very imperfect instrument compared with the human ear; its working is immensely aided by human intelligence, much in the same way that the gaps in the reproductions of the phonograph and graphophone are supplied by the knowledge of what must be the sequence, and that words must be supplied; much as the foreigner understands the slurring of the German genders or French particles by the American tourist.

The telephone relay, too, must take this imperfect rendering of speech, and being also an instrument with similar parts—that is, being provided with a diaphragm more or less damped by transmitting devices—might put an additional burden on human intelligence.

A telephone relay may work in a laboratory when treated with due consideration and with experimental skill; but in practical use its vagaries will receive no charity; the occupant of a room in the Waldorf-Astoria wishes to communicate with Chicago with the same instrument that he uses to speak to the office in the hotel; and the telephone engineer does not wish to add to the complexity of an already heavily-loaded system.

From the engineer's point of view substitution on different lines of different instruments adapted to the peculiar conditions on various lines is not favored either in telegraphy or telephony; in this respect practical methods depart widely from scientific methods. The theoretical electrician adapts his instrument to the conditions of the experiment. When telegraphy and telephony become more refined arts a variation in instruments will probably take the place of the present uniformity.

Turning now to the working of the relay with which I have been experimenting, I will speak of its working without entering into a detailed account of its construction, further than to say that the diaphragm holds a very minute solenoid in a balanced magnetic field and that the diaphragm actuates a transmitter.

Fig. 4.—FILLING THE ELECTRICALLY-HEATED BREAD OVEN.

The articulation of this instrument used as a relay on all lines within the compass of a laboratory is as good as that of the ordinary telephone; the wonder is that, with its diaphragm loaded, it repeats so well the articulation given to it; for it is a mechanical ear and must superimpose its own gaps upon those transmitted to it. Through the courtesy of Mr. Hammond Vinton Hayes, engineer of the American Telegraph and Telephone Company, the instrument was tried on the line between New York and Boston.

The relay being placed at the middle of the line, a comparison was made of its working with the ordinary instruments used on the line without break. On such a line the working of the relay proved inferior to that of the ordinary telephone with its transmitter.

On such a comparatively short and comparatively good line the conditions were too exacting for this relay; for the original transmitting instruments showed no failure in loudness and articulation. Why should one, therefore, expect to surpass such working by the use of an instrument with the additional impediment of a loaded diaphragm?

In all cases, it seems to me, where any relay method is compared with the working of the ordinary instrument on the unrelayed line, the message must be given to the relay before the electrical energy has fallen too low and before the articulation has, by reason of great capacity and unbalanced conditions, become inarticulate although still loud.

I have experimented with a line representing the distributed capacity of a cable of about forty miles in length, on which the working of the relay surpassed both in articulation and loudness the working of the ordinary telephone instruments. The relay was placed at the middle of the line, the ordinary instruments were used in comparison on the undivided line.

The experiments with the relay on such a line developed the interesting fact that high notes were transmitted better by the relay over half the line, than by the ordinary instruments over the undivided line; a boy's voice was much clearer than a man's deep voice. The attenuation coefficient was less for high notes than for low notes.

With the improvements contemplated in this form of relay there seems to be prospect of its practical use on lines similar in character to that I have described; that is, unloaded lines of considerable length.—The Electrical Review (N. Y.).

TELEGRAPH AND TELEPHONE SYSTEMS IN JAPAN AND CENTRAL STATIONS.

It will be generally admitted that the degree of civilization which a nation has reached may be observed by the development of its means of communication. This remark can be well applied to Japan, for in less than a quarter of a century that country has established a system of telegraph and telephone lines which is as widely extended and as well operated as the European systems. It was only about thirty years ago that Japan commenced to profit by the advantages of Western civilization. It called upon European and American professors and teachers, who taught the different sciences as well as their application in practice. The Japanese has a remarkable aptitude for such studies, as was found, and they devoted all their energy and ardor to profit by the new instruction. They have a remarkable intelligence and possess a great faculty of assimilation, being also diligent in working. In a few years the Japanese acquired an amount of knowledge for which other nations would have needed a whole generation, and showed that they had scarcely any further need of education in order to continue their rapid evolution in progress and civilization. Thus as regards telegraphy and telephony, Japan is now self-sufficient, and has no more need of foreigners for directing the large companies which have been formed. The rapidity with which these two branches of electrical work became developed is quite remarkable. The most curious fact which is to be observed is that formerly the Japanese found no need of a more rapid and practical means of communication, seeing that the government was obliged to compel their use by law during the first stages.

The first telegraph engineers who were called to Japan came from England in 1868, and at the end of 1869 the first telegraph line from Tokio to Yokohama was laid and operated. For a period of ten years after this there was nothing more accomplished in the way of telegraphy. The government even considered it as a "devil's invention." At the time of the civil war, when the feudal system of Japan was destroyed in the great revolution which took place, the services which telegraphy could render became better appreciated and this awakened a great enthusiasm for the new method of communicating at a distance. Accordingly, as soon as the war was ended the government took up the matter in earnest and greatly extended the system. The Japanese lines were connected with the international system and in 1879 Japan formed part of the International Telegraph Union. All the large cities rivaled with each other to have a telegraph station, and it was found difficult to satisfy all of them at once. The government accordingly obliged them to contribute to the expense of installation. In spite of such contributions the demands of the different cities became more pressing and numerous and it was necessary to establish new lines. The entire system was completed in 1884. A period of only five years had sufficed to cover the whole country, and the number of lines was greater than that of Italy. In the following period the connections with foreign countries were greatly extended, involving the laying of submarine cables to connect Japan with Corea. Then a system was established to the island of Formosa. Afterward a connection was made from there to China. During the recent war with China a number of military lines were laid and these have since been used for commercial purposes.

During the first period the personnel of the telegraph system was entirely made up of foreigners, but

since 1879 it is exclusively Japanese, only employing English engineers for laying the submarine cables. Since 1890 even this difficult work is done by the Japanese. A number of cable-laying ships are in use, and these are equipped with modern apparatus. As regards the Japanese telegraphic material in general, the line construction does not differ very much from that of Europe. Pine or thuya wood poles are used, and these are impregnated with sulphate of copper to preserve them from rotting. The poles last ten years or more. Porcelain insulators are used. At first iron wire was employed, but at present nothing but copper or bronze is used.

The first telegraph apparatus in Japan came from America in 1852, and it was followed by Breguet (French) apparatus in 1869. A short time after, the Austrian administration proved the value of the Morse instruments, which were definitely adopted in 1873 and a construction shop was erected. This establishment was able in the next five years to turn out all the apparatus which was needed for the Japanese lines. From that time on all the instruments are of home make. The telegraph lines now have a total length of 18,000 miles, which is equal to 80,000 miles of wire. There are at last accounts 2,500 telegraph offices in the country, using 4,500 apparatus. As to the traffic upon the lines it is noted that in 1902 the number of messages sent in the interior is 15,000,000, besides 500,000 messages on the international system and 2,000,000 messages for the operation of the lines. This is to be compared with Italy, which gives a total of only 12,000,000 messages.

The establishment of the telephone in Japan is of a more recent date. Its progress is even more remarkable that that of the telegraph. The first experimental telephone line was run in 1890 from Tokio to Yokohama, and it is curious to note that the interurban line preceded the urban. But a few years were needed for the Japanese to appreciate the other "devil's invention," for in a short time a very extensive system was installed, and not later than 1901 there were 78,000 miles of urban lines, 6,000 of interurban (in 66 lines) 25 central stations, 179 public telephone cabins, and 25,000 subscribers. Since that time the system has greatly increased. In 1901 there were 80,000,000 of urban messages and 1,000,000 interurban, which shows how extensively the telephone is used.

The above facts show very clearly with what ardor the Japanese are taking up the most progressive methods. As concerns the electric lighting and power plants, we may cite the example of Tokio, which possesses a central lighting station which is equipped with engine and dynamo units to the extent of 5,000 horse-power. This will soon be increased to 9,000 horse-power to keep up with the increasing use of the current, and the plant will rival the best European stations. The number of subscribers for electric light is constantly on the increase and reaches a mean of 1,500 per month. There is no doubt that the station will soon need a capacity of 10,000 horse-power. An electric tramway has been running for several years in Tokio and is meeting with great success. This is due to the fact that the Japanese prefer to live in the suburbs of the city, where their houses are surrounded by gardens. It is easy to foresee that in a few years the central stations of Japan will take colossal proportions, as in America. A large hydraulic plant is now in construction. The current will be utilized for lighting in three of the neighboring towns. Power is furnished by the Tama River. At Osaka an extensive tramway system is now being installed. Among other new projects it may be mentioned that before long a power transmission line will connect Shainawaga and Kanawaga, two large towns which lie 20 miles apart.—L'Electricien, Paris.

COPERNICUS.*

By Edward S. Holden, Sc.D., LL.D., Librarian of the U. S. Military Academy.

Nicolaus Copernicus was born in Thorn, a town of Prussian Poland, on February 19, 1473. His father, Niklas Koppernigk, was a merchant of Krakau who established himself in Thorn about 1450, and there married Barbara, the daughter of Lucas Watzelrode, a descendant of an old patrician family. The father was chosen alderman in 1465—a testimony of his worth. He had four children: Barbara, who died abbess of the Cistercians at Culm; Katherina, who married a merchant of Krakau; and two sons, Andreas and Nicolaus.

We know little of the childhood of Nicolaus. In 1483 his father died and he was placed in the care of his uncle, another Lucas Watzelrode, who was called to be Bishop of Ermeland in 1489, and with whose career that of Copernicus is closely bound up. The boy was educated in Thorn till his nineteenth year, when he was placed in the University of Krakau. The greatest illustration of its faculty was Albertus Blar de Brudzewo (usually written Brudzewski), professor of astronomy and mathematics. The works of Purbach and of Regiomontanus were expounded in his lectures. In the winter semester of 1491-92 Copernicus was matriculated in the faculty of arts, and devoted himself, so it is recorded, with the greatest diligence and success to mathematical and astronomical studies, becoming, at the same time, familiar with the use of astronomical instruments. In the autumn of 1494 Brudzewski left the university, and it is probable that Copernicus did the same. The humanists of the faculty had suffered a defeat at the hands of the scholastics, and the latter now ruled supreme. At Krakau Copernicus studied the theory of perspective, and applied it in painting. Portraits from his hand are praised by his contemporaries.

In the summer of 1496 the youth went to Italy, and in January, 1497, he was inscribed at the University of Bologna, in the "Album of the German Nation," as a student of jurisprudence. From 1484 to 1514 the professor of astronomy at Bologna was Dominicus Maria da Novara. He was an observer, a theorist, as well as a free critic of the received doctrines of Ptolemy, although such of his criticisms as we know are not especially happy, it must be confessed. He determined the obliquity of the ecliptic to be 23 deg. 29 min. by his own observations, which is in error by 1 min. 20 sec. only, a small quantity for his time. Copernicus was received by him on the footing of a friend and helper, rather than as a pupil; and the association was, without doubt, of great benefit to the younger man. All the systematized knowledge of the time was opened to him; what was known was examined and discussed, not received uncritically. Best of all, observation was practised as a test of theory and as the only basis for its advancement.

The first recorded observation of Copernicus is an occultation of Aldebaran by the moon in 1497 at Bolonga; in 1500 he observed a conjunction of Saturn with the moon at the same place, and a lunar eclipse at Rome. Other eclipses were observed in 1509, 1511, 1522 and 1523; and positions of Venus, Mars, Jupiter and Saturn in 1512, 1514, 1518, 1520, 1523, 1526, 1527, 1529, 1532, 1537. These recorded observations extend over a period of forty years. Though they are few in number, there is no reason to doubt that they are merely excerpts from a more considerable collection. They were made with very simple wooden instruments constructed by the observer's own hands. One of them, a triquetem, was sent as a present to Tycho Brahé in 1584, forty-one years after the death of Copernicus. It was made of pine wood, eight feet long, with two equal cross arms. They were divided, in ink, into 1,000 equal parts, and the long arm into 1,414 parts. This precious relic, together with a portrait of Copernicus, was long preserved in Tycho's observatory at Uraniborg, and finally removed to Bohemia, where it perished in the confusions incident to the Thirty Years' War (1618-1648).

Rheticus once urged upon him the need of making astronomical observations with all imaginable accuracy. Copernicus laughed at his friend for being disturbed about so small an error as a minute of arc, and declared that if he were sure of his observations to ten minutes, he would be as pleased as was Pythagoras when he discovered the properties of the right-angled triangle. Copernicus determined the latitude of Frauenburg to be 54 deg. 19½ min., which is 2 min. too small. This seems to us a large error. Even with his instruments he could have been more precise if he had repeated his observations many times. But the determination was excellent for the times, as we may see by remembering that the latitude of Paris was given by Tycho as 48 deg. 10 min., by Fernel as 48 deg. 40 min., by Vieta as 48 deg. 49 min., by Kepler as 48 deg. 39 min. His calculated longitude of Spica Virginis, which he took as a standard star, was 40 min. in error. He concluded that Krakau and Frauenburg were on the same meridian—an error of 17½ min. of arc. The observations of Albategnius, five centuries earlier, were far more precise, and this was not entirely owing to the superiority of the Arab instruments.

At the University of Bologna Copernicus mastered Greek. The knowledge was subsequently utilized in a translation into Latin of the epistles of Theophylactos Simokatta (630 A. D.), which he printed in 1509. This was the only work published by him in his lifetime. The translation is said to be elegant, but the book itself is of comparatively little importance. He had studied it at the university and utilized his knowledge. The book upon which his fame rests—"De Revolutionibus Orbium Cœlestium"—did not appear until the very day of his death, and was published by the care of others. Scipione dal Ferro, the discoverer of the general method of solving the cubic equation, was in residence at Bologna at the same time, and there is little doubt that Copernicus met him also, although there is no record of the meeting. In recording this name we seem to be well out of the middle age. A general solution of the cubic belongs to the modern period, although the Arabs were working on the question in the tenth century.

In 1497 Copernicus was appointed Canon of Frauenburg, which assured to him, for life, an income corresponding to about $2,250 of our money of to-day, and a leave of absence of three years was granted him to continue his studies in Italy. At a later date he also received a sinecure appointment at Breslau. He had already taken the lesser vows; to the higher he never was dedicated. In 1499 his brother Andreas was likewise consecrated Canon of Frauenburg, and he also matriculated at Bologna (1498) in the faculty of law. Both brothers were represented at home by substitutes, and considerable expense may have attached to this, but it is curious to note that on account of the costly living at the university they needed, and received, remittances from the bishop, their uncle.

In the summer of 1500 his leave of absence expired, and in company with his brother he crossed the Alps to Frauenburg, where both received a new permission to return to Italy. It was stipulated that Nicolaus should study medicine after the completion of his courses in law, in order that he might serve as physician to the Frauenburg chapter. In the autumn of 1501 both brothers were again in Italy, Andreas at Rome, Nicolaus at Padua. The doctor's degree in jurisprudence was conferred upon Nicolaus in 1503, but he remained in Italy till the year 1505 or 1506—nine or ten years in all.

In the archives of Ferrara we read:

"1503. Die ultima mensis Maij. Ferrarie in episcopali palatio, sub lodia horti presentibus testibus vocatis et rogatis Spectibili viro domino Joanne Andrea de Lazaris siculo panormito almi Juristarum gymnasii Ferrariensis Magnifico Rectore, Ser Bartholomeo de Silvestris, cive et notario Ferrariensi. Ludovico quondam Baldassaris de Regio cive Ferrariensi et bidello Universitatis Juristarum civitatis Ferrarie, et alijs.

"*m*: Venerabilis, ac doctissimus vir Nicholaus Copernich de Prusia Canonicus Varmensis et Scholasticus ecclesie S. crucis Vratislaviensis: qui studuit Bononie et Padue, fuit approbatus in Jure canonico nemine penitus discrepante, et doctoratus per prefatum dominum Georgium Vicarium antedictum etc.

promotores fuerunt
D. Philippus Bardella et
D. Antonius Leutus qui ei dedit insignia
cives Ferrariensis etc."

In the year 1500 Copernicus delivered lectures at Rome before an audience of two thousand hearers, the Archbishop of Mechlin declares. These lectures could not have announced the heliocentric theory, which dates from the year 1506 only, nor could they have been before the university, because Copernicus did not take the degree that admitted him to the privilege of teaching until 1503. He took no degree at Krakau, so far as is known.

Copernicus was now quite free to prosecute his studies in medicine, which he combined with philosophy. The celebrated Pomponazzi was then a member of the faculty, in the prime of his vigor. He had taken his degrees in philosophy and medicine at Padua in 1487, and in the next year, when he was but twenty-six years of age, had been chosen extraordinary professor. It was a custom of those days to choose two professors of each subject in order that their public disputations might stimulate their hearers to independent thinking. The ordinary professor of philosophy was Achillini—a veteran of the strict school of Aristotle.

Pomponazzi remained at Padua until the university was closed in 1509; and in Ferrara till 1512, when he removed to Bologna, where in 1516 he wrote his famous treatise on the "Immortality of the Soul"—the foundation of his character as a skeptic and of his fame as a philosopher. Into his doctrines it is not necessary to enter at length. Briefly they are that man, standing on the confines of two worlds—the material and spiritual—necessarily partakes of the nature of both. Man is partly mortal (since the human soul depends in some degree on matter) and partly immortal. The soul is, Pomponazzi says, absolutely mortal, relatively immortal. This doctrine was, of course, a denial of the theory of the Roman church. He was vehemently attacked. His book was burned in Venice. Powerful friends among the cardinals protected him in Rome. His university stood by him and confirmed him in his professorial chair for eight years, and increased his salary to 1,200 ducats.

Pomponazzi was a thinker of essentially modern spirit. Reason, he said, was superior to any authority. If, in his teaching of Aristotle, he should find himself in error, "ought I," he says, "to interpret him differently from my real sentiment? If it is said, 'The hearers are scandalized,' well, be it so. They are not obliged to listen to me, or to forbid my teaching. I neither wish to lie, nor to be false to my true conviction." He decides, on psychological grounds, against the immortality of the soul, and then proceeds to build up a system of practical ethics resting on philosophy. Belief is not needed as a basis for ethics—not by cultured men, at any rate. He is the first writer within the Christian communion to attempt to establish morality on a foundation of reason. He is a Stoic. "The essential reward of virtue is virtue itself," he says; "the punishment of the vicious is vice, than which nothing can be more wretched and unhappy." Future rewards and punishments are not invoked.

It is worth our while to pause here and reflect that we are hearing a teacher to whom Copernicus listened; to whom all Italy, nay, all Europe, attended. This teaching was permitted in Italy. It influenced thousands upon thousands of hearers. Perhaps the tolerant treatment of Lutherans in Ermeland by Copernicus when administrator of his diocese may have had its origin in ideas received at this time.

There were other men in the faculty with a message for pupils of genius. Aristotle and Plato were expounded from original Greek texts, and the mazy fabrics of the commentators were swept away. Fracastor, who was, by and by, to become an opponent of the heliocentric theory, was a teacher there. He was the first to teach that the obliquity of the ecliptic changed uniformly (1538), in which respect—only—his doctrine was more sound than that of Copernicus. 'Medicine was expounded by four professors, and dissection of the human body was practised. Marc Antonio della Torre, the instructor of da Vinci, was one of the anatomists. So far as is known, Copernicus did not take his doctor's degree in medicine.

He was, however, skilled in physic, after the fashion of his day, and practised the art during all his life. He was considered, some of his biographers say, "a second Æsculapius." We know nothing definite of his medical practice until his later years. From 1529 to 1537 he treated Bishop Ferber, who praises him as the preserver of his life. Duke Albrecht of Prussia called

* From Popular Science Monthly.

him to Königsberg in 1541 to treat one of his court, and it is of record that the patient recovered.

It does not appear that Copernicus returned to Frauenburg before 1506. He was then thirty-three years of age. All that the world had then to offer in the way of culture was his. He had followed university studies in theology, philosophy, logic, medicine, mathematics, and astronomy. He had mastered Greek, and practised painting. He had been the friend or pupil of the greatest teachers of Italy for ten years, and was now established as physician to his uncle in the bishop's palace at Heilsberg, in high station, with an assured income. Up to this period he had shown no original power; but there can be no doubt that he was universally regarded as a man of the highest culture.

His relation to his uncle was that of Achates to Æneas, affectionate and intimate. The Bishop of Ermeland was a great noble in a place of power. Affairs of much import to the Church had to be treated. The knights of the Teutonic order (founded at Acre in 1190) had conquered the Duchy of Prussia in the thirteenth century. West Prussia had been ceded to Poland in 1466, while East Prussia, including Ermeland, was a Polish fief. A part of the policy of the order was to extend the lordship of their metropolitan Bishop of Riga over the diocese of Ermeland. It was the policy of Bishop Lucas to oppose all such efforts, to attain entire independence, and even to become spiritual over-lord of a part of the territory of the Teutonic order. These plans came to nothing; but a legacy of hatred remained among the knights, who left nothing undone to provoke and degrade the Ermeland bishop and his friends, and to excite disorder in his own territory. The pressure of the invading Tartars on the borders kept the knights occupied, however, and left them little leisure for hostile action. Constant vigilance was required on the part of the bishop, and many journeys to different parts of the bishopric were required.

Copernicus was charged with missions of this sort from the very first. It was during one of these journeys to Petrikau in 1509 that he printed his Latin version of the "Epistles" of Theophylactos. Greek epistles—invading Tartars—feudal rights—church privileges—Polish and Prussian politics—these were the preoccupations of his mind. We can hardly think that much time was left for astronomy, yet the lunar eclipse of June 2, 1509, was duly observed. One of Copernicus's biographers calls him "a quiet scholarly monk of studious habits—in study and meditation his life passed—he does not appear as having entered into the life of the times." This is the legend. It is obviously only a small part of the truth. In March, 1512, the Bishop of Ermeland died and Copernicus returned to his cloister at Frauenburg. He was now thirty-nine years old.

In the dedication of his "De Revolutionibus" to the Pope (1542), Copernicus says that it is now "four nines of years" since the heliocentric theory was conceived. Strictly interpreted this brings the date of its birth to 1506. It is, at all events, safe to say that the idea was elaborated on German, though it may have been born on Italian, soil.

From 1512 to 1516 Copernicus was in constant residence at the Cathedral of Frauenburg, where indeed the greatest part of his life was spent. For two periods (1516-19 and 1520-21) he lived at Allenstein, administering certain estates belonging to his chapter. His observatory was on one of its towers and commanded a wide horizon. Few observations were necessary for his great discovery of the heliocentric motion. He knew beforehand the phenomena to be explained. Ptolemy had offered a solution that had been accepted for fourteen hundred years. Would any other hypothesis explain them? In the first place, Copernicus affirms the rotation of the earth on its axis. The rising and the setting of the stars is caused by this.

The question of the rotation of the earth had been examined by Ptolemy. He rejects the notion, saying: "If the earth turned in twenty-four hours around its axis every point on its surface would be endowed with an immense velocity, and from the rotation a force of projection would arise capable of tearing the most solid buildings from their foundations and of scattering their fragments in the air." The force of projection depends, we know, not only on the absolute velocity of points on the turning earth (and this velocity is immense), but also on the angular velocity about this axis. The latter is slow. The hour hand of a clock turns twice as fast as the earth. The projective force at its maximum is just sufficient to diminish the weight of a ton by six pounds. A feeble force of the sort is not fitted to tear trees up by their roots or buildings from their foundations, as Ptolemy supposed.

Copernicus adopted the theory of a rotating earth, although he was no better able than Ptolemy to explain the difficulty. The science of mechanics was not born till the time of Galileo. The reasoning of Copernicus is: "The rotation of the earth being a natural movement, its effects are very different from those of a violent motion; and the earth, which turns in virtue of its proper nature, is not to be likened to a wheel that is constrained to turn by force." He seeks to escape the difficulty by a trick of scholastic philosophy. No other issue was open in his day. Examples of this sort are well fitted to give us a vivid idea of the state of science in those times. It was not easy for our predecessors to take a forward step. More honor to them that the steps were taken.

In the preface to the "De Revolutionibus" Copernicus declares that he was dissatisfied with the want of symmetry in the theory of eccentrics and weary of the uncertainty of the mathematical conditions. Searching through the works of the ancients, he found that some of them held that the earth was in motion, not stationary. Philolaus, for example, taught that the earth revolved about a central fire.* Copernicus makes no mention of the theory of Aristarchus. We must assume that he did not know it, though his ignorance in this respect is hard to explain. We have no list of his library, which was, however, extensive for the time.

"Then I too," says Copernicus, "began to meditate concerning the motion of the earth; and although it appeared an absurd opinion, yet since I knew that, in earlier times, others had been allowed the privilege of imagining what circles they might choose in order to explain the phenomena, I conceived that I also might take the liberty of trying whether, on the supposition of the earth's motion, it were possible to find better explanations of the revolutions of the celestial orbs than those of ancient times. Having then assumed the motions of the earth that are hereafter explained, by long and laborious observation I found at length that if the motions of the other planets be likened to the revolution of the earth, not only their observed phenomena follow from the suppositions, but also that the several orbs, and the whole system, are so connected in order and magnitude that no one part can be transposed without disturbing the rest and introducing confusion into the whole universe." He looked, he here says, for a new theory because the old one was unsymmetric; and his new theory satisfies because it consistently explains the facts of observation and because it was symmetric. Symmetry of the kind referred to is not essential to a true theory. If any theory explains every fact of observation quantitatively as well as qualitatively, it is to be accepted. Copernicus was not free from hampering presuppositions any more than his predecessors.

"We must admit," he says, "that the celestial motions are circular, or else compounded of several circles, since their inequalities observe a fixed law, and recur in value at certain intervals, which could not be unless they were circular; for the circle alone can make that which has been recur again." In writing this passage his mind was closed to every idea but one. Copernicus knew, far better than most of us, that ovals and ellipses might also serve to represent recurring values, but the thought did not even cross his mind in connection with celestial motions. He was committed to circular motions exclusively, from the outset.

"We are therefore not ashamed to confess," he says, "that the whole of the space within the orbit of the moon, along with the center of the earth, moves around the sun in a year among the other planets; the magnitude of the world (solar system) being so great that the distance of the earth from the sun has no apparent magnitude (is indefinitely small) when compared with the sphere of the fixed stars. . . . All which things, though they be difficult and almost inconceivable, and against the opinion of the majority, we, in the sequel, by God's favor, will make clearer than the sun, at least to those who are not ignorant of mathematics."

The system of Copernicus required thirty-four circles and epicycles—four for the moon, three for the earth, seven for the planet Mercury and five for each of the other planets. Cumbrous as this apparatus appears to us, it was a distinct simplification of the Ptolemaic system as taught in the sixteenth century. Fracastor, writing in 1538, employed sixty-three spheres to explain the celestial motions.

One word must be said of the theory of trepidation which Copernicus accepted. The precession of the equinoxes was discovered by Hipparchus by comparing his own observations of stars with preceding ones. He saw that the longitudes of the stars changed progressively and fixed the annual change as 1 degree in seventy-five years. Later observers determined the amount of precession by comparing their own observations with preceding ones. The motion of the origin of longitudes—the equinox—is really uniform. An unlucky Jew—Tabit ben Korra—in the ninth century, came to the conclusion that the motion was not uniform, but variable, sometimes at one rate, sometimes at another. The variable motion was the trepidation. Copernicus admitted the reality of this phenomenon and thereby introduced a fault. Tycho Brahé, who had no important data on this point that was inaccessible to Copernicus, rejected the idea of trepidation and freed astronomy from a blemish that had endured for centuries.

It is impossible and unnecessary to exhibit in this place the details of the heliocentric theory of Copernicus. In Kepler's account of Copernican astronomy there is a section on the explanation of the retrogradations of the planets. "Here," he says, "is the triumph of the Copernican astronomy. The old astronomy can only be silent and admire; the new speaks and gives rational account of every appearance; the old multiplies its epicycles; the new, far simpler, preserves everything by the single motion of the earth around the sun." In describing the stationary points of the planets he declared: "Here the old astronomy has naught to say."

We must try to put ourselves in the place of the students of those days who heard the two explanations of the world—the geocentric and the heliocentric—expounded by the same professor in the same lecture room as alternative hypotheses. Each hypothesis offered a possible explanation. That of Copernicus was so simple that its intellectual acceptance was immediate. It was possible; but was it true? If it were accepted, what implications did it bring in its train? The real difficulty was moral, not intellectual. Was the whole edifice of Ptolemy to be destroyed? No—some of it was indubitably true. If some, why not all? What was to become of the authority he had held for a thousand years? Was all knowledge to be made over? Even the idea that part of the "Almagest" was true and part false was not to be lightly accepted.

The conception that every physical problem has one and only one solution was also entirely new; until it was fully received students balanced one explanation against another, and even held two at once, strange as this may seem to us with our new standards in such matters. The heliocentric theory eventually prevailed not because the logic of Ptolemy was broken down, but because all mere authority was weakened. The dicta of philosophers were looked at in a new light. It was not, in fact, generally received until the day of Newton, though it was sufficiently established by the observations of Galileo and convincingly by the calculations of Kepler. To actually demonstrate the rotation of the earth on its axis we must have recourse to an elaborate experiment like that of Foucault on the pendulum, or to comparisons of the force of gravity in different latitudes; to demonstrate its revolution round the sun it is necessary to measure the time required for light to reach us from the distant planets, or to evaluate the aberration of the light of the fixed stars. It was not easy for the sixteenth century to make a decision. If the heliocentric theory were true, then the planet Venus must show phases like the moon; but no phases could be seen. It required Galileo's telescope to show them. Moreover, the fixed stars must have annual apparent displacements in miniature orbits. None such were visible; none were detected until 1837, when Bessel determined the parallax of a fixed star (61 Cygni) for the first time. Galileo sought for them in vain; so did Herschel; so did other astronomers of the eighteenth century with their splendid instruments. The conception of epicycles was retained in the "De Revolutionibus," and it seems to us a blemish; to the contemporaries of Copernicus it was a mere analytic device. Newton explains one of the inequalities of the moon's motion by an epicycle, in the "Principia."

It is only when we thus consider in detail how the new ideas must have presented themselves to the students of the sixteenth century that we can comprehend the real obstacles in the way of their acceptance. A genius like Kepler could receive them simply on their intellectual merits. Men in general required time to change their point of view, and to accept a novel and essentially disheartening theory. Ptolemy's system of the world was compendious, comfortable, so to say, and easily understanded of the people. Man's central position in the universe flattered his pride and allayed his fears.

Peter the Lombard (1100-60) expresses the accepted view in its baldest form: "Just as Man is made for the sake of God, that is, that he may serve him, so the Universe is made for the sake of Man, that is, that it may serve him; therefore is Man placed at the middle point of the Universe, that he may both serve and be served." The new view made man an outcast and placed him in immense and disquieting solitudes. Pascal has phrased the new and anxious fear: "Le silence eternal de ces espaces infinis m'effraie."

Astronomers needed accurate tables of the planetary motions in order to predict eclipses and conjunctions. The Alphonsine tables were quite unsatisfactory. The theory of Copernicus was made the basis of new tables—the Prutenic tables—by Reinhold in 1551, and they remained the standard until 1627, when the Rudolphine tables, based on Kepler's theories and Tycho's observations, superseded them. The doctrines of Copernicus were spread by means of almanacs based upon Reinhold's tables rather than by his theoretical works; and they made their way quietly, surely and without any great opposition. Tycho proposed a new (and erroneous) system of the world in 1587. It also had its effect in weakening the authority of Ptolemy. The motions of comets began to be observed with care. It was clear that the doctrine of material crystal spheres would not allow room for their erratic courses. In one way and another the authority of the ancients was broken down and the way prepared for the eventual triumph of the theory of Copernicus.

It is interesting to note the opinions of Englishmen of the sixteenth and seventeenth centuries. Francis Bacon rejected the new doctrines; Gilbert of Colchester, Robert Recorde, Thomas Digges, and other Englishmen of the time of Queen Elizabeth, accepted them. Milton seems to hesitate in "Paradise Lost" (book viii.), which was written after 1640, though he had visited Galileo in Florence in 1638, where, no doubt, Galileo proved the Copernican theory to him by word of mouth. At all events he thoroughly understood it as his description of the earth

" . . . that spinning sleeps
On her soft axle, while she paces even
And bears thee soft with the smooth air along"

abundantly proves, since in the last line one of the chief objections to the theory is answered.

The heliocentric theory gained powerful auxiliaries in Moestlin, professor of astronomy at Tübingen, and in his pupil Kepler. In 1588 Moestlin printed his "Epitome," in which the mobility of the earth is denied; but he accepted the new views probably as early as 1590. Kepler writes: "While I was at Tübingen, attending to Michael Moestlin, I was so delighted with Copernicus, of whom he made great mention in his lectures, that I not only defended his opinions in our disputations of the candidates, but wrote a thesis concerning the first motion which is produced by the revolution of the earth." In 1596 Moestlin, in a published

*The central fire of Philolaus was, however, not the sun; for in his theory the earth, the sun, the moon and all the planets revolved about a fire so placed at the center of the system as to be forever invisible to the earth.

epistle, expressly adhered to the heliocentric theory of the world.

Luther emphatically declared his opinion of the Copernican theory on several occasions. He calls Copernicus "that fool" who is trying to upset the whole art of astronomy; and refers to Joshua's command that the sun should stand still as a proof that the earth could not possibly be the moving member of the system. Melanchthon, a far more learned man, declared that the authority of scripture was entirely against Copernicus. The attitude of the Roman Church was more indifferent at that time, not more tolerant. Tolerance comes with enlightenment; and both Protestant and Catholic doctors were, in general, profoundly ignorant of science. When we are thinking of the attitude of the church we must remember that the conflict with Galileo had not arisen. Calvin quotes the first verse of the ninety-third Psalm, "The world also is established, that it cannot be moved," and says: "Who will venture to place the authority of Copernicus above that of the Holy Spirit?"

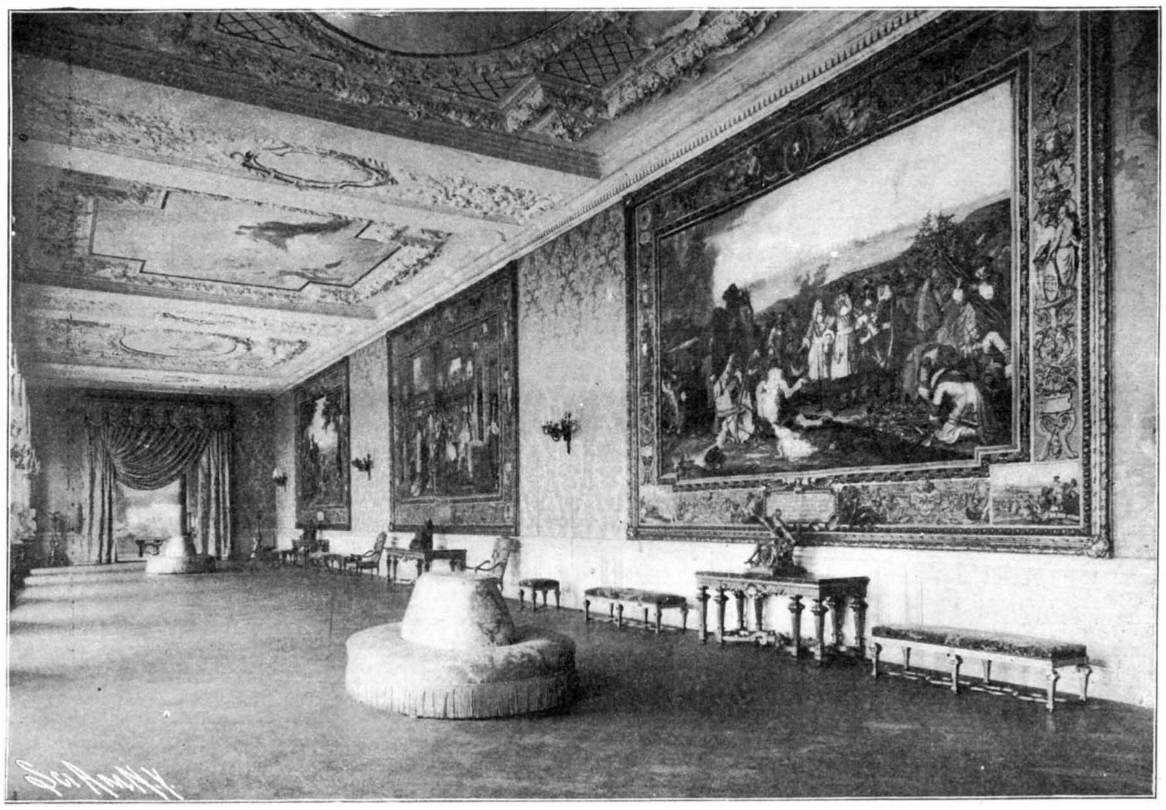
Such dicta of great theologians are often quoted to demonstrate the existence of an age-long conflict between science and religion. So to interpret them is a sad misconception of the real warfare that has occupied mankind for ages. The veritable conflict has been between ignorance and enlightenment, not in one field only, but in all conceivable spheres.

Before there can be fruitful discussion the "universe of discourse" must be defined. Things of a like kind can alone be compared. The world of science relates and refers to material things moved by physical forces; and only to these. The world of religion relates and refers only to immaterial things moved by spiritual energies. These worlds are wide apart now. They were widely separated even in the sixteenth century, and they were entirely divided for the highest thinking men even in the middle ages. In either world conflicts are possible. They can only take place between ideas of the same kind—between religion and heresy, or between science and pseudo-science. Theologians decide the issue in one world; men of science in the other. It is the business of philosophers to define and discuss the limits of each world in turn; to determine the validity of conclusions. It is the privilege of poets harmoniously to express imagined analogies between the action of spirit on spirit and of force on matter. It is the dream of seers and prophets to synthesize such analogies into a single system, mingling two universes into one. Whatever may be our hope for the future, the synthesis has not yet been achieved. Theologians have essayed it from one direction, philosophers from another, but the essential distinction remains untouched. There is a world of matter; there is a world of spirit. Men live in both. Their actions are ruled by different and discrepant laws. In the world of spirit the good man is safe and happy, no matter what fate may befall him in the world of physical phenomena. In the latter world no virtue will save man who transgresses its especial laws. Gravitation, and not goodness, decides whether his falling body suffers harm or is preserved alive.

To Calvin the pronouncement of Copernicus was sheer blasphemy. It seemed to him to lie entirely within the sphere of religion. Judged by the accepted standards of that sphere it was audacious heresy. To Kepler the law of Copernicus lay entirely within the sphere of science. It was to be accepted as true, or rejected as pseudo-science entirely by scientific criteria. Calvin's words fell within one universe of discourse, Kepler's in another. There was no conflict between religion and science as such. Calvin sat as judge of a conflict between religion and a possible heresy. Kepler asked himself if this new assertion was substantial truth or merely error masquerading in a scientific form. Phenomena cannot be judged by criteria belonging to a world to which they are foreign. It is in a light like this that we must examine the relations of such men as Copernicus and Galileo to their times.

The Lateran council (1512-17) appointed a committee to consider the much needed reform of the Church calendar, and in 1514 the help of Copernicus was asked—a proof that he was not only remembered in Rome, but that his reputation had grown since his residence there. He declined to give advice, for the reason that the motions of the sun and moon were, as yet, too imperfectly known. At the request of the chief of the committee, Copernicus continued his researches on the length of the tropical year—a fundamental datum.

(To be continued.)



THE COURT OF HONOR IN THE FRENCH NATIONAL BUILDING, SHOWING THE GOBELIN TAPESTRIES.

FRENCH PAVILION AND GARDENS AT THE ST. LOUIS FAIR.

By the St. Louis Correspondent of the SCIENTIFIC AMERICAN.

ALTHOUGH the French exhibits in the various exhibition palaces of the St. Louis Fair, and particularly in the Fine Arts Building, are of great excellence, the choicest and most characteristic display consists of the splendid Government Pavilion and Gardens, of which we present an illustration. Copied after the Grand Trianon at Versailles, this structure is richly illustrative of French architecture in the Renaissance. It is designed after the fashion of a chateau that was built by Louis XIV. for Madame de Maintenon.

The architect of the original Trianon was Mansard, who is famous for having invented what we call Mansard roofs, and who was one of the best-known architects of his day. All the government manufactories aided in furnishing and decorating the building; the Gobelin and Beauvais people sent their most beautiful tapestries, the Sevres factory some of its rarest porcelains, and the state Garde-Meuble sent all the furniture and hangings for the grand gallery of honor.

The "Salon de Société Nationale des Beaux-Arts" in the south wing has no furniture except curtains, carpets, and puffs in gray velvet. The features of this salon are the allegorical paintings by G. Dubufe, the famous French artist, president of the French National Society of Fine Arts. The principal painting covers the entire south wall. It includes three panels—a big center panel representing the Apotheosis of Victor Hugo, with the catafalque of the great poet under the Arch of Triumph, and two side panels, the one on the left being devoted to Alfred de Musset, and the one on the right to Lamartine.

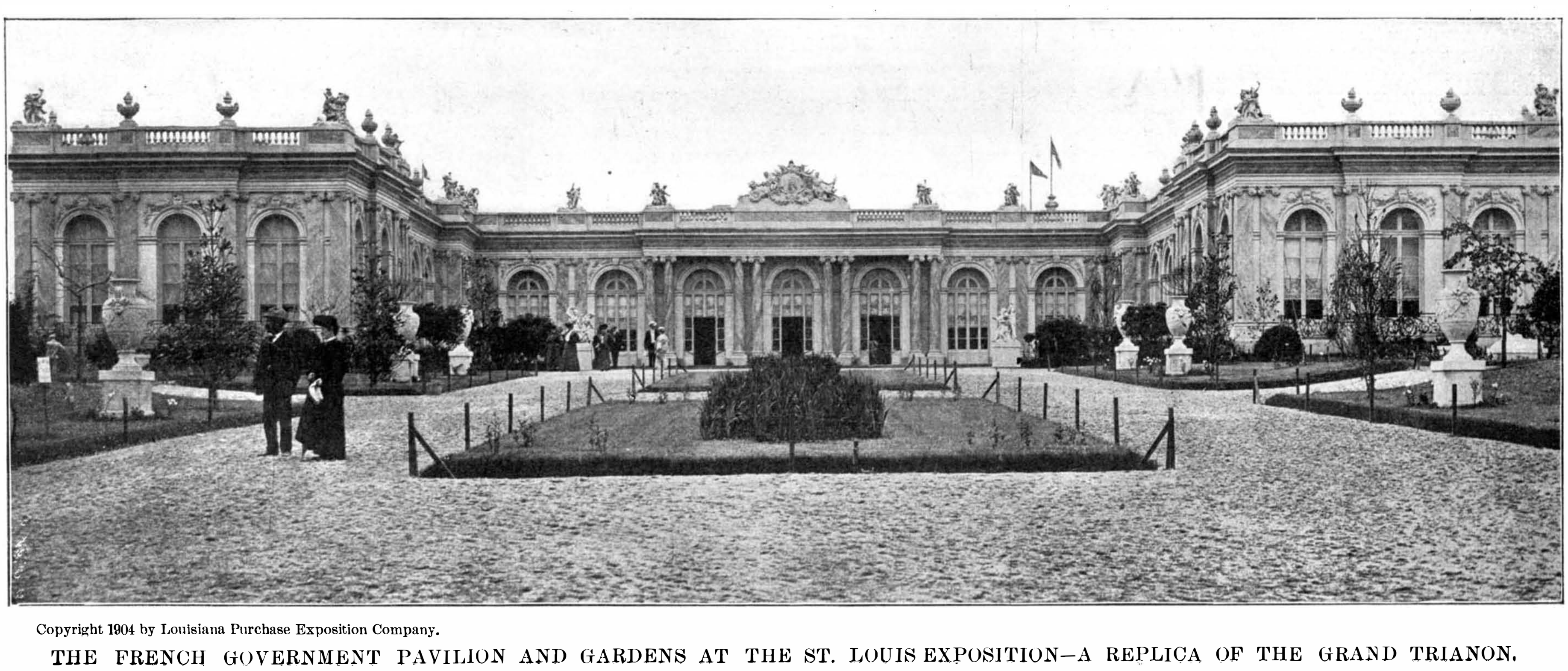
On the opposite side and between the high windows are two panels representing Architecture and Engraving. The painting on the west wall represents French Music and the French Songs. On the opposite wall is a symbolic painting with the Latin inscription: "Ars Galliae Humanum Decus." The ceiling painting represents France, who goes through the night bringing light and progress.

The "Salon de la Manufacture Nationale de Porcelaine de Sevres" is in the northern wing of the building. It contains some of the most beautiful porcelain wares the world has ever produced. In the corners of the room are four vases six feet high by Bienville and Fournier, and around the Salon are statuettes in biscuit.

In the "Salon de la Ville de Paris," which occupies the two other rooms of the northern wing of the building, two large panels, "Notre Dame de Paris" and the "Pavilion de Flore," are shown. In the center of the wall is a painting by J. M. Auguste Leroux, representing the Thermæ of the Roman Emperor Julian, which are in Paris. Under this painting is a beautiful example of artistic wrought iron by L. Bergeotte. On the other side is a "Hunting Diane" by Louis Priou. Paintings representing views of the city of Paris, including the Place de la Bastile, the Rue de Rivoli, the Bois de Boulogne, and the Musée de Louvre, complete the exhibit.

The priceless old Gobelin tapestries, brought from the Garde-Meuble Museum in Paris for the walls of the Hall of State, were used to decorate the Grand Trianon at Versailles during the reign of Louis XIV. The Hall of State is entirely furnished in the style of Louis XIV., even to the candelabra and the door and window fittings. The tapestries have all the appearance of paintings, although silk and metal alone are used in the weaving of them. The titles of each tapestry are woven into the fabric at the bottom.

The treatment of the French gardens about the



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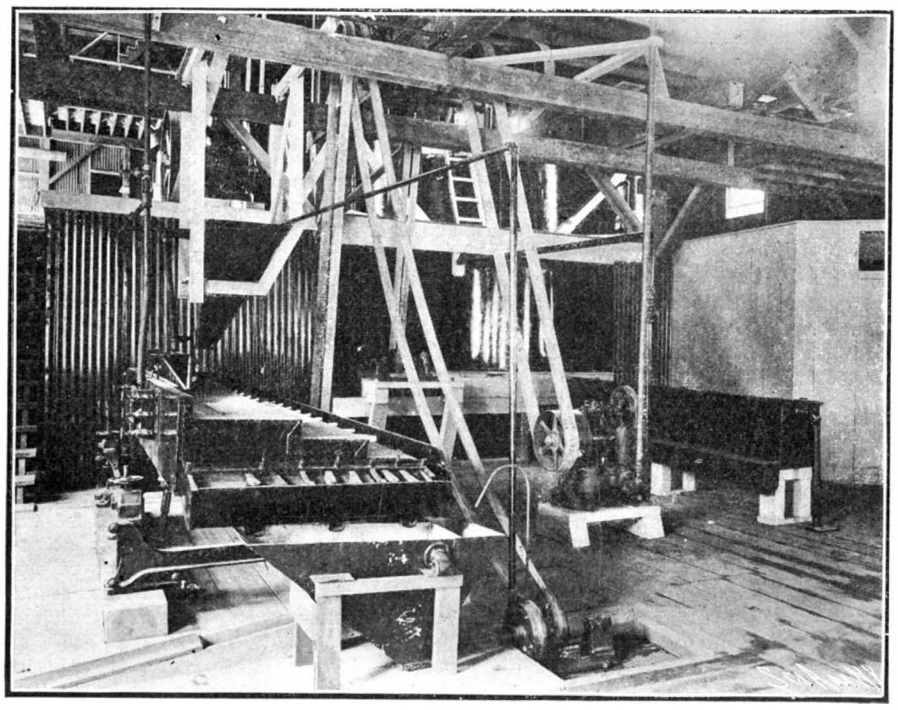
THE FRENCH GOVERNMENT PAVILION AND GARDENS AT THE ST. LOUIS EXPOSITION—A REPLICA OF THE GRAND TRIANON.

Grand Trianon gives an idea of the very elaborate plans upon which all the foreign gardens are projected. The French Government Reservation covers fifteen acres. Extending the entire front of the reservation, on University Boulevard, is a beautifully-wrought iron grille fence, made by the first manufacturers in France. The grand entrance at the head of the great transverse boulevard employs eight openings. The center of the driveway entrance is the full width of the drive, leading up a gentle slope to the court of the Trianon. It is flanked on either side by raised terraces of sward. Pink graveled walks traverse the crests of the terraces in rectangular lines. The slopes along the driveways and tableland of the terraces are done in the finest example of French floral embroidery.

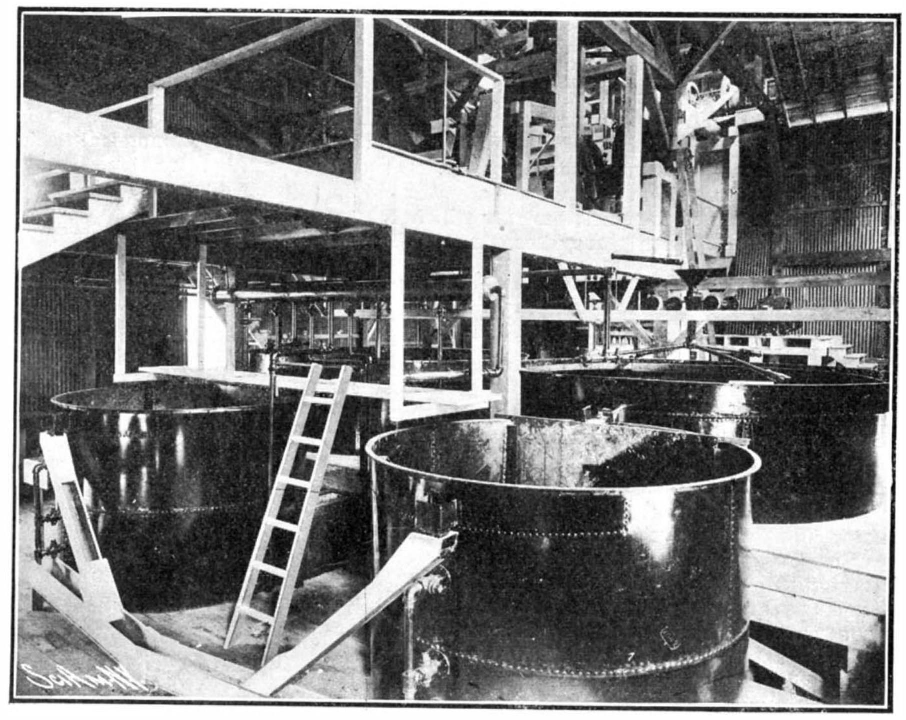
THE MINING EXHIBITS AT ST. LOUIS FAIR.

By the St. Louis Correspondent of the Scientific American.

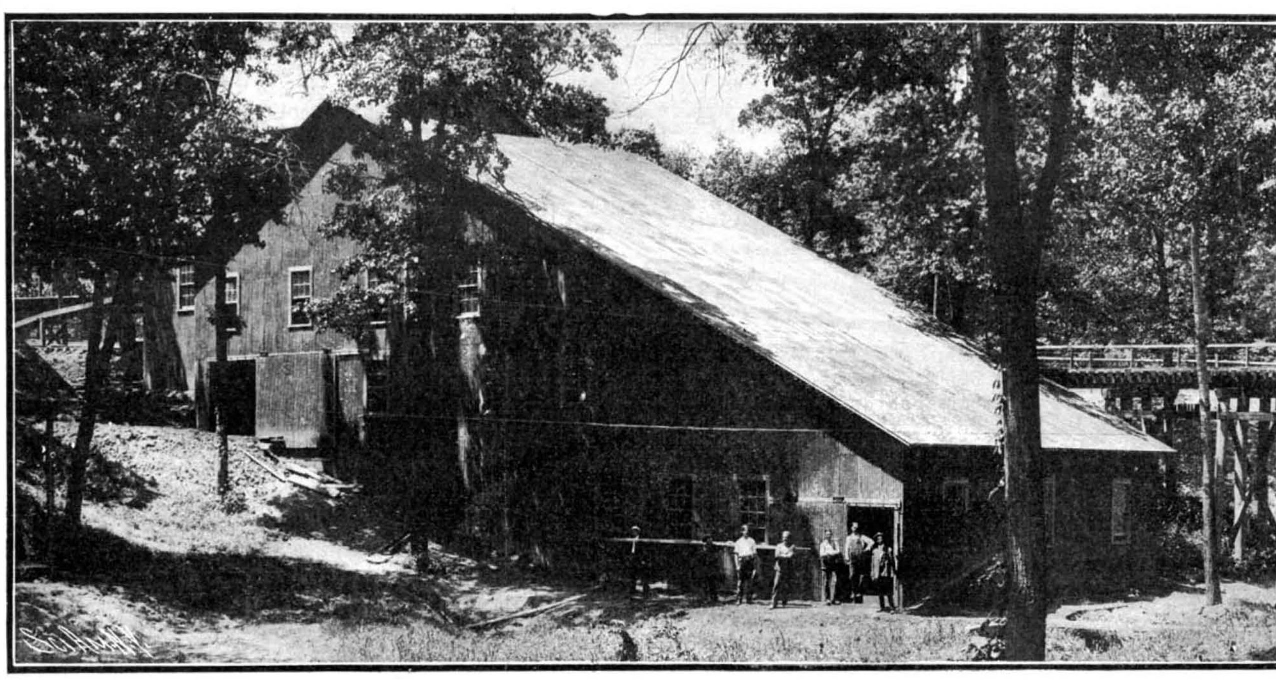
Advantage was taken, in laying out the World's Fair, of a rather deep depression that runs through the heavily-wooded portions of the ground, to construct a series of practical mining exhibits, which are so arranged as to render the name "Mining Gulch," by which this district is known, a very appropriate and distinctive designation. Mining Gulch supplements the elaborate exhibit which is gathered in the Mines and Metallurgy Building, and it might broadly be said that while the latter shows the products and implements of the miner's art, the Mining Gulch illustrates the practical application of these tools in mining the ore, handling and transporting the same, and recovering the metals, precious and otherwise. Among other notable exhibits in the Mining Gulch may be mentioned a government fuel-testing plant; a rope tramway exhibit which is carried across the gulch; an exhibit by the government of a tie-preserving process, and also a government timber-testing plant. The Californian exhibit shows a stamp mill, amalgamating and concentrating machinery, and also an early-day mill brought from California, consisting of an overshot wheel and a stamp mill. There is also an outside display of Missouri minerals; a typical Missouri zinc and lead mill; a large exhibit showing a typical Pennsylvania anthracite coal mine, with 1,750 feet of underground workings; an Arizona mining camp, showing all the picturesque features of mining life, including a typical mining dance hall; a New Mexico turquoise mine exhibit; a fine exhibit of traction engines and well-drilling machinery; a most interesting working exhibit of old-time Mexico copper smelting, shown in operation by a group of Mexicans; a fine exhibit, located near the mouth of the Mining Gulch, by the Colorado School of Mines. In a corral within the Gulch is a large herd of typical mining burros, which are hired out for the purpose of carrying visitors through the Gulch exhibit; and last, there is a fine exhibit of a rock mining electric railroad, which runs through the whole length of the camp, for the purpose at once of conveying visitors and displaying this system of traction. It is impossible to speak in detail of these various interesting exhibits, and, therefore, we have chosen as representative of the high quality of the displays, the exhibit of a typical Black Hills gold reduction plant. This plant was erected for the purpose of demonstrating the methods of gold reduction as carried out in the Black Hills gold-mining district. Ore from Black Hills, Dakota, to the extent of 1,500 tons, which has been gathered from various mines of the district, is being treated at this plant. It is first carried to a 9 x 12-inch crusher of the Blake pattern, the ore, after crushing, passing through a 1½-inch ring into a bin, from which it is fed by a disk feeder, with a positive feed proportionate to requirements, to a five-stamp battery of the Homestake pattern. The stamps weigh 1,000 pounds each, and have a 7-inch drop at the rate of 94 strokes per minute. The mortar is of what is known as the "close" pattern. The crushed material passes through screens of 16 to 24 mesh, and if the ore is of the amalgamating or free-milling type, the crushing is done in water. After passing through the screen, the product flows over 14 feet of silver-plated copper, where the majority of the gold is amalgamated. The crushed ore then is carried by an elevator up to the separating floor, where it is treated by one of three different methods, any one of the methods being shown according to the wishes of the spectator. On the separating floor, the sand is separated from the slimes, which consist either of clay or very finely ground sand. The object of the separation is to take out only such material as is coarse enough to be workable by the leaching process. On the sand floor, the material is passed into two sand tanks alternately, the tanks being 8 feet in diameter and 4 feet in depth. Each has a three-sectional filter bottom of canvas. The slimes that have been separated out are carried to two slime tanks alternately. All slimes carrying gold are accumulated in what is known as a gold tank, from which they are passed through an iron sectional zinc box, where the gold in solution comes in contact with zinc shavings and is precipitated. The product is treated with sulphuric acid and roasted to eliminate the zinc, after which it is ready for fluxing or melting, which process is carried out every Saturday during the fair, the product being reduced to bullion. Should the ore contain iron pyrites, it is treated on the Bartlett concentrating table. This exhibit also includes a complete laboratory, with an assay outfit and melting furnace.



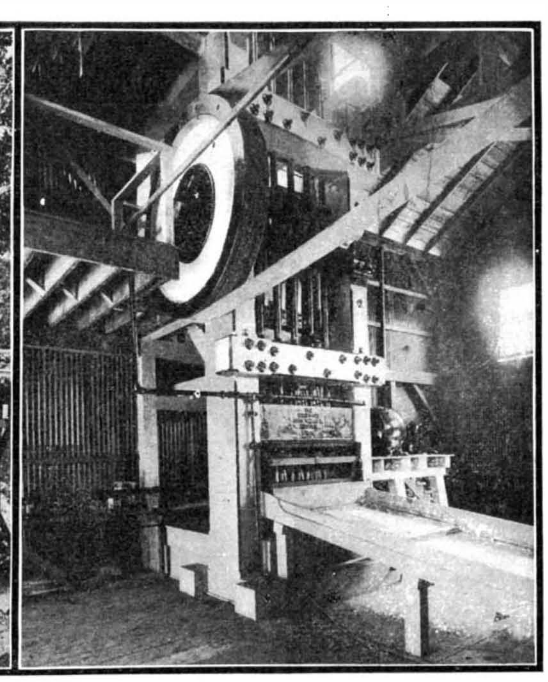
PRECIPITATION ROOM, WITH ZINC BOXES ON RIGHT AND THE CONCENTRATING TABLE TO THE LEFT.



SAND AND SLIME VAT FLOOR, WHERE THE LEACHING OF THE GOLD TAKES PLACE.



SOUTH DAKOTA, SOUTH HILL, GOLD REDUCTION PLANT.



THE FIVE-STAMP BATTERY; CAPACITY 15 TO 25 TONS PER DAY.

MINING EXHIBITS AT THE ST. LOUIS FAIR.

OCULAR EXPERIMENTS WITH PINHOLES.

There is much to be learned from studying the aspect of Nature through a pinhole. The apparatus is easily procurable, and not costly. It consists of a piece of thin black or dark-colored paper and a pin. Having made a puncture, place the paper as close as possible to the eye, so that the aperture is on the optical axis. In this position the optical system will resemble that of a single lens with a small stop, as used in photography. The first thing to be noticed is that whereas with the naked eye it is impossible to see objects situated in different planes directly at the same time, with the pinhole planes widely separated will be all distinct. It will be found, too, that printed matter can be read with ease, placed as close to the pinhole as is consistent with obtaining enough light on the paper, and short-sighted persons will be able to distinguish letters beyond their normal sight. With a pinhole, short, long, and normal-sighted persons all see alike. An interesting experiment is to take a lens of positive focus—an ordinary reading-glass or a photographic lens answers equally well. It will be found that using the lens as a microscope the object has to be placed at something less than the solar focus, and then the lens magnifies. Using the lens as a telescope everything is blurred, but the interposition of

a pinhole between the eye and the lens restores definition, and there is no sensible magnification. A corollary of this experiment is that provided a small enough stop be used, not necessarily to the extent of a pinhole, a lens may be placed at such a distance from the plane of the plate that nothing is in focus with a normal aperture and yet a reasonably sharp image may be obtained. This is quite practical. If one has, for instance, a 7-inch lens, and to include sufficient of the subject a 5-inch lens would be required, all that is necessary is to adjust the position of the lens and screen so as to include the amount of subject required, disregarding the confused image, to stop down sufficiently, and to give the requisite exposure. The rough-and-ready method of making a pinhole above prescribed serves for the ocular experiments detailed; but the scientific making of a pinhole for photographic work is a matter entailing considerable technical skill. —The Photogram.

GENERAL ORGANIZATION OF SOLAR RESEARCH. CONTINUOUS REGISTERING OF THE VARIABLE ELEMENTS OF THE SUN.*

By H. Deslandres.

The study of the sun, which has been neglected for so long a time, is now attracting general attention. American science, especially, under the energetic impulse given by Langley and Hale, is directing the great instruments and considerable resources at its disposal toward the sun. Before long the general organization of solar study is to be discussed at the St. Louis congresses. I present here my personal opinion upon this important question, which I have already treated in a number of previous memoirs, and for which I have been prepared by fourteen years of continuous observations of the sun.

The study of the sun is not only of interest for savants, but is also of general interest, for the periodic variations of the solar surface which extend in still greater measure to its atmosphere, also extend to a great degree to the atmosphere of the earth and the soil. The great problem of the division of time is partly connected with our data upon the sun. Whence the necessity of giving the greatest possible extension to solar study. These considerations may be reduced to the following statement: *It is necessary to read and register in a continuous manner all the variable elements of the sun*, in the same way as in meteorology for certain elements of the atmosphere and the soil. The solar apparatus we have are more complicated, but they may also be less numerous. The rapid examination of the actual observations of the sun shows that the preceding programme is far from being realized. In general the study is confined to the surface, which is easy and uses simple apparatus. The surface observations are very numerous, but often of little use, as they are badly systematized. This remark does not apply to the fine series of views obtained at several observatories, such as Meudon and Lyons, nor above all to the excellent series of photographs obtained in England with identical apparatus in three observatories separated by a considerable distance. The observation is not yet continuous, although the variations are sometimes rapid around the spots.

The solar atmosphere is a more complex and difficult subject of study. It is divided into two parts, exterior and interior atmosphere. The three layers which compose it in the sense of height are divided into exterior and interior reversing layer, exterior and interior chromosphere and outer and inner corona. Since 1868 the exterior chromosphere and the protuberances are easily studied by ocular observation with the spectroscope, and since that date they are noted once each day in two Italian observatories. Other observatories are also carrying on the same work, but without any understanding with the precedent. The protuberances have more rapid variations than the spots, and would gain still more by a continuous photographic registering. The inner atmosphere of the sun is the most important and also the most difficult to observe. It necessitates the co-operation of photography and of special and costly apparatus with automatic movement, known as *spectro-heliographs* or *double-slit spectrographs*. For this reason this kind of observation has not been organized, as far as I am aware, except in the two observatories of Yerkes and Meudon, near Paris, to which we may join the private observatory of Evershed. The apparatus isolates the ray of a solar vapor by a second opening or slit and with it reconstitutes the image of the vapor itself. With the H or K ray of calcium, which was isolated first, it gives the image of the entire inner and outer chromosphere. The Meudon Observatory possesses the series of chromospheres which have been photographed since 1893 at Paris and at Meudon (in general a single plate per day). The Yerkes Observatory also has many good series. But the apparatus can also isolate the black bands, as I found in 1894, so as to have the interior layer. In general, for the black bands, it is necessary to have larger telescopes and more powerful apparatus, and the Yerkes Observatory is working at present toward this end. As the solar specter has more than 20,000 black bands, this makes a very wide field of observation and leads to a knowledge of all the successive layers of vapor of the interior atmosphere and perhaps even of the corona. The observation is carried out by photography, and can easily be adapted to a continuous registering method.

Another apparatus which completes the preceding, and which I call the *speed-taking spectrograph*, has been established at Meudon. It registers the movements of the solar vapors in the direction of the earth. This apparatus, which operates by automatic movement, is not yet as complete as might be desired, on account of the insufficience of the funds which have been allotted for this work. For the same reason it only works in an intermittent manner. However, it is not sufficient to observe the forms and the movements of the solar matter; we must follow the intensity of its radiation. Several observers, Crova especially, measure the total calorific radiation; on the other hand Langley registers the intensity of determined regions of the spectrum. But both of them are brought to the probable conclusion that the radiation varies in intensity with time. The importance of this study and the necessity of carrying it on without stopping are evident. In this direction there is still much to be done. The ultra-violet solar radiation remains to be studied; this is important on account of its electric action. Also the effects of the electro-magnetic solar radiation, then the cathodic radiation and the emission of electrified particles (ions and electrons) by the sun. To sum up, the present researches now being carried on concerning the sun need a great improvement and extension, and other interesting researches have not as yet been organized. I have thus been led to the following propositions: First, it is desirable to organize as soon as possible the union and co-operation of astronomers for all questions relating to the sun, in order to bring out the best value from each observation and the easy comparison of the results. In France, the Solar Commission of the Astronomical Society has already made an effort in this direction, by requesting all its members to make their solar photographs of the same dimensions and obtained under as nearly identical conditions as possible. But a general Astronomical Congress alone would be able to form a series of simple rules which could be followed by all, and to make the proper distribution of the work to be undertaken. This would be even better done by a permanent association, which would be organized, like similar associations, under the control of the International Association of Academies. The Solar Association would have its annual meetings in which all nations would be represented, and by the vote of its members it would decide all questions relative to the sun. The solar question is an international one, in the nature of things.

Second, the interior solar atmosphere offers an extremely wide field of research which is scarcely yet explored, and it promises great results. This work should be recommended to establishments which possess sufficient means. The measurement of the radiation should be especially attended to. We must follow the valuable researches of Crova and organize, either from mountains or balloons, the measurement of the ultra-violet radiation and the ionizing power of the solar rays. Third, the solar observation should be continuous and obtained as much as possible by photographic registering, like the observations of the earth's magnetic field. I already proposed, in 1893 and 1894, automatic apparatus for the continuous registration of the surface and the lower mean and upper chromosphere. But these apparatus are more expensive to establish than the ordinary apparatus and also more costly to maintain, on account of the increase in the personnel and in photographic products. The expense was considered too high, but nevertheless it is not above the resources of a large country. It could be supported by the International Association which I proposed above.

Fourth, the solar registering instruments should be established on the most favorable points of the globe, where the brilliancy and sharpness of the photographs would be greater than in our temperate climates. I have already pointed out the great advantages which the high plateau region and the desert of Algeria would present from this standpoint. The high plateaux of a relatively easy access are numerous in that country, and the most important condition, namely, the dryness of the air, is well fulfilled. Fifth, the International Association would have among its secondary functions that of determining the exact sense of the usual terms which are defined in an incomplete manner, and of fixing the best terms to be used for new cases. Take, for instance, the word *protuberance*. Does it designate only the elevated prolongation above the chromosphere or the *ensemble* formed by this prolongation and its chromospheric base, which are physically inseparable? The two parts have the same specter and the chromosphere is most brilliant at the base of a protuberance. Hale uses the word only in its restricted sense, while I have often given the wider sense, but seemingly avoiding all ambiguity. In a discussion some misunderstanding might arise from this cause, which would be avoided by a precise definition. I note also a certain confusion in the terms which designate the new images of the solar vapors, and the apparatus which produce them. These latter apparatus have been called by Hale *spectro-heliographs*, and this name has come into use. However, the objection can be made that the apparatus can be used with any kind of source as well as the sun. As the characteristic of the instrument lies in its second slit, I called the apparatus the *double-slit spectrograph*, but would rather propose the name *spectro-heliograph* or *spectromobile* for all these instruments, with the addition of the following simple terms: (a) with one or two slits; (b) monochrome or polychrome; (c) for forms or speeds; (d) with prism or grating. These terms give a general idea of the nature of the instrument.

The images of the atmospheric vapors have also received widely different names. Hale calls the brilliant parts of these images "bright spots," supposing them to be emitted by the vapors confounded with the highly incandescent portions. Since 1903 he gives them the name of *flocculi*, referring to their form. In turn, I have always considered them as emitted by the vapors of the atmosphere, and have called them *faculary flames*. I propose the word *faculide*, which is shorter. There are many terms which need to be more definitely fixed.

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CLIMATE AND GLACIERS.

By Prof. Dr. R. von Lendenfeld, of Prague.

The formation and growth of ice caps and glaciers depends upon the amount of snowfall and of loss through melting and evaporation. If the annual precipitation in solid form exceeds the annual loss, a permanent snow field is formed. The snow of which this consists becomes transformed gradually into ice, and the excess is protruded in the form of glaciers into the zone in which loss exceeds gain.

If the annual loss is equal to the annual gain, the fallen snow does not accumulate, and there is no formation of ice and glaciers. The region of preponderating gain is called the snow region, and its boundary is the snow line.

The gross increment or annual snowfall increases with lowness of temperature, moisture, and the inclination of the wind to the horizon; the losses, on the other hand, increase with warmth and dryness.

As the air is warmed only very slightly by the direct action of the sun's rays, but chiefly by contact with the heated ground, the temperature falls as we ascend. There is also a gradual decrease of temperature from the equator to the poles, as the sea and land surface becomes more oblique to the sun's rays.

If the earth's surface were everywhere level and composed of the same materials, the result of these two laws would be a uniform lowering of temperature with increasing elevation and latitude. But this surface is neither level nor of uniform constitution. It is part land, part water, and the land masses are very irregular in form and distribution, both horizontally and vertically. These irregularities produce corresponding irregularities in the law of decrease of temperature.

The alternation of land and sea and the irregularities of coast lines affect the regular decrease of the mean annual temperature toward the poles by breaking up the ocean currents, turning branches of the warm current toward the poles and branches of the cold current toward the equator. Such a diverted current is the Gulf Stream, which causes a considerable increase of mean temperature on the coasts which it washes.

The uniformity of decrease of temperature with increase of height is affected by irregularities in the vertical arrangement of the earth's surface. This decrease is more rapid in the free atmosphere and on narrow and steep mountain ranges like the New Zealand Alps than on the gentler slopes of widely extended table lands.

In regard to the influence of the temperature upon the development of glaciers, it must be noted that the intensity and duration of cold weather, that is, of temperatures below the freezing point, can hardly have an appreciable effect, and that the extent of glaciation is chiefly dependent on the intensity and duration of warm weather, or temperatures above the freezing point.

In a uniform climate, where the seasons differ little in temperature, the winter being mild and the summer comparatively cool, temperatures both above and below 0 deg. C. will be numerically smaller than in a climate of the same mean annual temperature but greater difference between the seasons, the winter being severe and the summer hot. Now, as the degree of temperature below zero does not affect glaciation, while the degree of temperature above zero influences both the snowfall and the amount of melting, the development of glaciers will be the greater the more uniform the climate, the mean annual temperature remaining the same. The irregularities of the earth's surface affect not only the decrease of mean annual temperature upward and poleward, but also, and to a much greater degree, the annual variation of temperature.

The sea is less heated by the sun in summer and less cooled by radiation in winter than the land. In the vicinity of extensive surfaces of water, therefore, the winters are mild and the summers cool, the annual variation is small, the climate is *oceanic*.

In the interior of continents, on the contrary, the winters are severe, the summers hot, the annual variation great, the climate *continental*.

From this it is evident that the climate of small islands lying remote from continental masses must be uniform or oceanic, that a comparatively uniform temperature must prevail also on the shores of continents, and that the annual variation must increase toward the interior.

Europe forms the western edge of the Eurasian continent, and we know that on the west coasts of England and Ireland the winters are mild and the summers cool, while as we go eastward the difference in temperature between these seasons steadily increases. Dampness is dependent on temperature in so far as warm air is able to take up and retain more water vapor than cold air. Atmospheric humidity is therefore greatest, in general, in the tropics, whence it decreases toward the poles. But humidity is dependent also upon the nature of the earth's surface, it is greater over the sea than over the land, and, like the mean temperature and the variation of temperature, it is affected by the arrangement of oceans and continents. It is greater where a warm ocean current reaches a

high latitude than at other places of the same latitude, greater on small islands remote from land than on continents, and on the latter it decreases from the coast toward the interior.

The inclination of winds to the horizontal is due to heating and cooling of the air, as well as to the irregularities of the surface over which the wind blows. In the tropics and over sunny land masses elsewhere the air is heated and rarefied and ascends. The upper return current, which flows from the equator, above the trade winds, cooled and condensed in its passage toward the poles, falls to the earth in the temperate zone. A wind striking a mountain or cliff is forced upward and thus inclined to the horizontal, and, on the other hand, it has often been observed that a wind blowing over a mountain or plateau, on reaching the edge of the elevation, rushes down into the valley.

These vertical movements of the air cause changes in temperature either by mixing layers of different temperatures or through the cooling due to expansion on ascending and the heating due to compression on descending.

The capacity of the air to retain water vapor (its limit of saturation) is decreased by cooling and increased by warming. Hence upward movements of the air which involve cooling are followed by condensation of vapor to the liquid or solid state and a fall of rain or snow, but no such precipitation is caused by downward movements, which are attended by increase of temperature.

Precipitation, like humidity, decreases in general from the equator to the poles and from the ocean to the central parts of continents. As a rule, the winds that bring rain in the temperate zone are fragments of the return current from the tropics, which at first flows at a great height above the trades, but descends in the temperate zone, as was stated above. Because of the earth's rotation these air currents flowing from the equator appear in the temperate zones as westerly winds. When such a wind, after descending to the sea level, strikes a mass of land, it is driven upward until it has reached the highest point of the continent. In this ascent the air is expanded and cooled, so that it is forced to let fall much of its moisture. The precipitation thus produced will in general be greatest where the (westward) slope of the continent is steepest and the ascent most rapid. The air which has thus been robbed of most of its moisture in its passage over the western slope of the continent can produce little rain or snow on the eastern side. For this reason the west slopes of mountain ranges and tablelands have a greater rainfall than the eastern, and on large continents the precipitation, in general, decreases from west to east.

The longer the temperature remains below freezing, the greater is the proportion of the annual precipitation which falls as snow. In the polar regions, especially the Antarctic, the temperature is so low that the entire deposit, even in midsummer at the sea level, consists of snow.

In the tropics snow falls only at very great elevations, from 3,500 or 4,500 meters upward. In the zones which lie between these extremes a larger or smaller proportion of the annual precipitation falls as snow according to latitude, altitude, the season, and various local conditions.

We will now investigate the influence of all these circumstances on the development of glaciers in various parts of the earth.

In regard to decrease of temperature with increase of latitude and elevation, we note that in accordance with this the snow line, in general, is highest and the glaciers smallest in the tropics, and that the former descends and the latter increase as we approach the poles. Between latitudes 20 deg. S. and 20 deg. N. the snow line is found at heights of from 4,280 meters (on Mount Orizaba in North America) to 5,920 meters (on Mount Sahama in South America). In the northern hemisphere the snow line descends gradually until the fortieth degree of latitude is reached, very rapidly between the fortieth and fiftieth, and quite slowly again between the fiftieth and sixtieth. It does not fall to the sea level anywhere in the northern hemisphere.

In Franz Josef Land at 82 deg. N. it is still 100 to 300 meters above sea level.

In the southern hemisphere likewise, we find on going from the equator toward the pole, at first a slow, then a rapid, then again a slow descent of the snow line, but the sudden fall lies ten degrees nearer the equator than in the northern hemisphere, and in the Antarctic the line touches sea level.

Warm ocean currents flowing toward the poles do not cause a rise of the snow line or a shrinkage of glaciers, for the increased humidity and precipitation which such currents produce, simultaneously with increase of temperature, neutralize and often reverse these effects, lowering the snow line and enlarging the glaciers.

Glacial development, however, shows very clearly the effect of the difference between great and small annual variation in temperature, or between continental and oceanic climates. In the northern hemisphere, where the land masses occupy much space, a more continental climate, in the southern, with its relative deficiency in land surface, a more oceanic climate generally prevails. While in the northern hemisphere the snow line between the fortieth and fiftieth parallels lies at from 1,590 meters above sea level (Mount Baker in North America) to 3,810 meters (in the Caucasus) it is found at the same latitude in the southern hemisphere at heights of from 300 meters (Kerguelen Islands) to 2,380 meters (in northern New Zealand). The fact already mentioned, that in high south latitudes the snow line comes down to the sea, which it does not do in the Arctic, presumably not even at the north pole, is to be attributed in part to this climatic difference between the two hemispheres. And as the snow line is lower in the Antarctic than in the Arctic, so is the glaciation far greater. While there is little difficulty in reaching 70 deg. north, and at some places of 80 deg. N. the sea in summer is open and merely encumbered with moving pack ice and bergs, southward progress is stopped, as a rule, at 65 deg. or 68 deg. south, between Victoria Land and Edward's Land at 78 deg. S., by high walls of ice, and sea and land are alike covered by almost motionless glaciers.

Uniform climate and abundant precipitation produce a low snow line and extensive glaciation on non-tropical mountainous islands remote from continents; extremes of temperature and small precipitation produce a high snow line and slight glaciation on mountains in the interior of large continents. This is shown clearly by comparing the New Zealand Alps with the Tien Shan range, both of which are about 43 deg. from the equator. On the former, or oceanic peaks, the average height of the snow line is 2,000 meters and the glaciation very great, though these mountains (of the Aorangi group) are little more than 3,000 meters high. The largest glacier is 28 kilometers long, and the foot of the lowest only 213 meters above the sea.

On the Tien Shan in the center of the Eurasian continent, the average height of the snow line is 4,500 meters, and there is little glaciation, though the chief peak (Chan Tengri) is more than 7,000 meters high. The largest glacier is only 24 kilometers long, and the foot of the lowest is 3,300 meters above sea level. So at equal latitudes we find differences in level of 2,500 meters for the snow line and 2,100 for the glacier foot.

In a similar though less striking manner the increase of annual variation of temperature from the coast to the interior, and the decrease of precipitation on the same continent from west to east, find expression in the level of the snow line and the size of the glaciers. On the northern slope of the Pyrenees, at the western end of the Mediterranean mountain system, and near the Atlantic at 43 deg. N., the height of the snow line is 2,800 meters. Going eastward at the same latitude it rises to 3,810 meters in the Caucasus and 4,500 meters in the Tien Shan. The fact that the precipitation on the side of a mountain range exposed to the moist winds coming from the equator, which are southwest winds in the northern, northwest winds in the southern hemisphere, is greater than on the other side, often makes the snow line lower on the western, equatorial or warmer side than on the eastern, polar or colder side. The height of the snow line is 1,000 meters on the west, 1,300 meters on the east side of Sulitelma in Norway; in the Aorangi group in New Zealand it is 1,850 on the northwest and 2,100 on the southwest side.

Steep cliffs cause greater and more sudden vertical deviations of the wind than are produced by gradual slopes of equal height. The effect of this and of the more rapid decrease of temperature with increase of elevation in narrow and high mountain ranges is, in general, to make the snow line lower than on tablelands of the same height. But this does not make the glaciers of narrow ranges greater than those of plateaus, because glaciers have better conditions for growth on broad tablelands than on narrow and broken ranges.

In view of these facts we conclude that, though glaciation depends upon temperature and increases from the equator to the poles in accordance with the general distribution of heat, it is also most profoundly affected by humidity and the annual variation in temperature, which, in turn, are largely conditioned by the distribution of water and land and the form of the latter.

Not only does the height of the snow line in many places differ greatly from the value normal to the latitude, but it is subject, in one and the same place, to great variations, which appear as still greater fluctuations in the levels of glacier ends.

It is generally known that the ends of the Alpine glaciers are not fixed, but in continual motion. The ice streams recede steadily for years, and then advance. The recent fluctuations seem to be periodic and to agree—at least in part—with Brueckner's 35-year period. Whether greater variations have occurred during the last two thousand years or not is hard to say, for though there are traditions and indications of such variations in ancient and medieval times, they will scarcely bear critical examination.

Prehistoric glaciers were subject to far greater variations than occur now. It is known that large parts of Europe and North America were covered with glaciers in prehistoric times. Denmark, northern Germany and Russia, Scotland, northern and central England, Canada and the northern United States lay buried under a more or less continuous sheet of ice. At the same time immense glaciers filled the principal valleys of the Alps and extended far over the surrounding country. The glaciers of other mountains of the northern hemisphere were also larger then than now.

Examination of the trees left by prehistoric glaciers shows that they did not increase steadily to their greatest size and then diminish, but that periods of great development alternated with others in which the climate was milder and the glaciers small, perhaps smaller than at present.

Penck and Brueckner have proved that in the Alps four great glaciations, unequal in extent and separated by mild periods, have occurred. At the time of greatest glacial development the European ice sheet extended to the fiftieth parallel of latitude, the North American probably still further south, and the largest Alpine glaciers attained dimensions of from 3,000 (Inn glacier) to 5,000 (Rhine glacier) square kilometers.

From these data many have inferred that a continuous ice cap covered the globe north of the fiftieth parallel and that the more southerly ranges, like the Alps, were more strongly glaciated then than now. But this was not the case. The great ice cap, which radiated from the Scandinavian plateau, extended only to the Ural Mountains. On these, as well as east of them in Asia, no traces of an extensive and unilateral glaciation are found, and the most recent explorations of Sverdrup and Schei have extended this iceless region to the western part of the Arctic archipelago north of America.

The degree of glaciation was equally variable on the Eurasian mountains, and in no other northern range did the glaciers attain such magnitude as in the Alps. Those of the Pyrenees and the Caucasus did not, like those of the Alps, spread fan-wise over the lowlands. The glaciation on the mountains of central Asia was still less extensive, and even the North American ranges appear to have been glaciated far less than the Alps.

Traces of vast prehistoric glaciers are found also in the southern hemisphere. In the southern Andes at least two great glaciations, of unequal extent, have occurred. The western glacier of New Zealand once extended to the sea; and even the peaks of the Australian Alps, now quite free from ice, have been covered with glaciers at least once, perhaps twice.

Less trustworthy are the evidences of prehistoric glaciation in South Africa.

On the tropical ranges of Africa and America indications of former extensive glaciation have also been found, and H. Meyer has recently proved that the glaciers of Chimborazo and other peaks in Ecuador, at the equator, formerly descended 1,000 meters below their present limits.

Modern glacial fluctuations, at least such as conform to Brueckner's 35-year period, are almost certainly due to periodic variations in the intensity of solar radiation. Penck's suggestion that in both temperate zones, wherever traces of prehistoric glaciation are found, the snow line at the time of maximum glaciation lay uniformly about 1,200 meters lower than at present, and the evidence given above of a lowering of 1,000 meters at the equator, support the assumption that the great prehistoric as well as the small recent fluctuations were due to solar or other cosmical causes.

But, on the other hand, the great influence of the distribution of water and land and the shape of the latter upon climate, and hence upon glaciation, shows that terrestrial causes may suffice to explain prehistoric expansions of glaciers. The uniform lowering of the snow line in the glacial era, suspected by Penck, is not proven, and to me it appears not generally applicable. In New Zealand, according to my impressions, the lowering was not half as great as in the Alps.

Even extensive prehistoric glaciation at the equator does not prove the cosmical origin of the ice age. I at least have no doubt that an overflowing of the Amazon valley and other parts of South America would have sufficed to extend the Chimborazo glacier down to the level at which Meyer found traces of glacial action.

We may obtain a good representation of the great influence of local, climate-determining causes upon glacier formation, and a satisfying answer to the question whether terrestrial changes would or would not suffice to produce the extensive glaciation of the ice age in northern and central Europe, by imagining the present climatic and glacial conditions of the southern hemisphere to prevail in Europe. The New Zealand Alps have the same latitude (43 deg.) and height as the Pyrenees. On the assumption made the Pyrenees would have great glaciers coming down to within a few hundred meters above sea level, as New Zealand has now, and would therefore be more strongly glaciated than they actually were in the ice age.

The Patagonian mountains have the same latitude (47 deg.) as the European Alps, but are not so high. The Patagonian glaciers now reach the sea. With a similar local climate the glaciers of the Alps, because of the greater height, should be still more extensive. Here again the maximum glaciation of the ice age falls short of what would occur under the assumption made.

In Kerguelen Land (49½ deg. S.) the height of the snow line is 300 meters. Similar glacial conditions being assumed in the northern hemisphere, the Argonnenwald, the Odenwald, the mountains which surround Bohemia and the northern Carpathians at the same (northern) latitude would be more covered with glaciers than they were in the ice age. Even low-lying islands between 60 deg. and 70 deg. south latitude are entirely covered with ice. Under similar conditions the much higher Scandinavian tableland, at an equal distance from the equator, would be far more deeply covered and probably in condition to supply the surrounding lowlands with masses of ice as great as or greater than those which were spread over northern Germany in the ice age.

Europe, therefore, would be more covered with glaciers than it was in the ice age if it had the climate and the glacial conditions that now prevail at the same latitude in the southern hemisphere. A subsidence of the Eurasian continent by a few hundred meters would, on the one hand, produce a condition (increased water surface) which would make the climate much damper, more uniform, more oceanic, more

like that of the southern hemisphere; and on the other hand, the glaciation would be reduced to the measure which it actually attained in the ice age.

We see, therefore, that the data at our disposal do not give a definite answer to the question as to the cause of the ice age. They show, however, that such changes in the distribution of water and land and the form of the latter as occur in geological periods would suffice to produce, now in one region, now in another, the glaciation of the ice age. They do not disprove the assumption that these great glacial developments have occurred without change of the earth's surface and everywhere at once. If this is the case, the causes of the ice epochs must have been extra-terrestrial.

With no more certainty can we answer the more important question whether the glaciers will ever again attain such vast dimensions. Probably they will, and the sites of St. Petersburg, Berlin, and London will be buried under the advancing ice sheet, but not for a long while. Sufficient unto the day is the evil thereof; let us leave to posterity the dread of the imminent fifth glacial epoch!—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Himmel und Erde.

THE MECHANICS OF THE ATMOSPHERE.*

THE motion of the atmosphere at any time is admitted to be so complicated that any approach to a workable representation of it must necessarily be by steps. The motion at any time must be regarded as a temporary divergence from the average motion, and the question naturally arises, What is the nature of the average state of motion about which the actual state of motion fluctuates? We may approach the solution of this question in either of two ways; we may find out what the motion actually is or we may find what the forces are which, so far as we can tell, cause the motion, and trust to our knowledge of dynamics to compute the average motion from the average forces. As regards the latter method, it may be said that the dynamics of an elastic fluid moving on a rotating spheroid, however interesting, is beset with an extraordinary number of temptations to error, and the more humble ambition of trying to find out what the motion really is, although painfully laborious, has advantages which may be compared with the advantages which walking has as compared with the use of a flying machine.

In the early seventies of the last century, Clerk Maxwell set a question in a Cambridge examination to which I owe the inspiration of a number of lectures and examination questions. It was this: "Show how by observations of the motion of a body the resultant force acting upon it may be determined," and he added the luminous rider (I quote from memory), "A fish weighing ten pounds swims through the water with a uniform velocity of ten miles per hour, always in the same direction; find the resultant action of the water on the fish." As soon as one begins to think of answering these questions, and in particular of applying them to the relation between the controlling forces of pressure and the motion of the atmosphere, one realizes what pitfalls await the unwary. The most obvious remark in relation to the first question is that the motion at any instant tells us absolutely nothing whatever about the forces acting. Unless observations sufficient to determine the change of motion have been dealt with, nothing about the cause of motion is known. Yet, in spite of this rudimentary fact of dynamics, obvious enough when it is stated, I cannot help wondering how many students of elementary dynamics ever really get rid of the notion that if you find a body moving in a certain direction you must look for a force in that direction too; we are surrounded with examples to the contrary, but the study of dynamics, being mainly deductive, usually passes them by.

In meteorology it is impossible to avoid the consciousness of temptation to the converse error of expecting to find the motion of air in the direction of the recognized forces. The most obvious force is that due to pressure, and who can resist the temptation of thinking that the flow of air from a high-pressure area to a low-pressure area must be the dominant feature of atmospheric motion? Yet the one great inductive statement in connection with meteorology, Buys Ballot's law, warns us that if we trust to the direction of forces to indicate the direction of motion we shall certainly be misled. Motion along isobars, perpendicular to the gradient, is a closer representation of the actual state of things than motion along the gradient, along, that is to say, the direction of resultant forces.

There is no doubt that if we could arrest for a time the motion of the atmosphere, without altering the pressure, and let the air start again from rest, the direction of initial motion would be along the pressure gradients from high to low, but we have to deal with an atmosphere that has been moving for countless ages, and all that existing forces do is to maintain or disturb the average, or steady motion; if in those circumstances we find the motion taking place in the direction of the forces, we find a condition of things which ought not to be expected, and one which requires explanation.

The question arises as to what one ought to expect the steady motion to have become in course of time. To afford some idea of the answer to this question, let me refer to the four diagrams here reproduced. The first gives the average isobars for January at the earth's surface, and discloses no simple representation of steady conditions. There are the well known high-pressure areas about the tropics, and isolated regions of low pressure over the North Atlantic and Pacific; but when we look at Fig. 2, the isobars computed by Teisserenc de Bort for the 4,000-meter level, there is an indication of comparatively simple steady motion, namely, a motion round the polar axis from west to east, somewhat deviated, however, to south or north by land or sea areas. Now if we assume that the motion is along the isobars thus represented, so that the lines of the diagram practically represent lines of flow of air, we must remember that the motion on a rotating earth implies a certain normal acceleration of the air to keep it in its path, just as the bob of a conical pendulum requires an acceleration toward its equilibrium position to maintain its motion in a circular path. The effective horizontal acceleration of the air is $2\omega V \sin\lambda$, where ω is the angular velocity of the earth, V the velocity of the wind, and λ the latitude. Of the velocity at the 4,000-meter level we can only form an idea from the observed motion of the clouds, and, as far as we know, the only forces available to give the necessary acceleration are those due to the pressure distribution which Teisserenc de Bort has plotted. By equating the pressure gradient to the product of the density and acceleration we can determine V, and the values thus computed are shown in miles per hour by figures between the isobars on the diagram. They must not be confused with the pressures, which are given in millimeters. The average wind velocities thus computed are not at all unreasonable, and it follows that motion along Teisserenc de Bort's isobars at about fifty miles per hour is not at all an unreasonable representation of the average steady motion of the atmosphere at that level in the month of January. That the directions of motion are appropriate is confirmed by Hildebrandsson's report on cloud motion to the International Meteorological Committee.

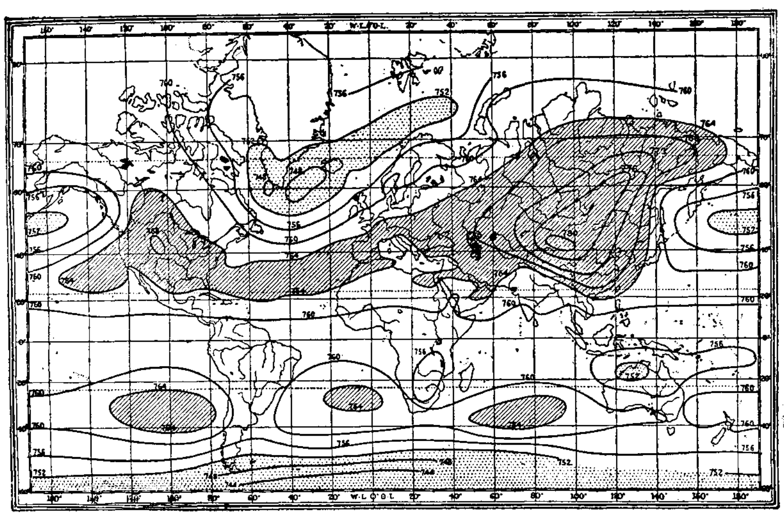
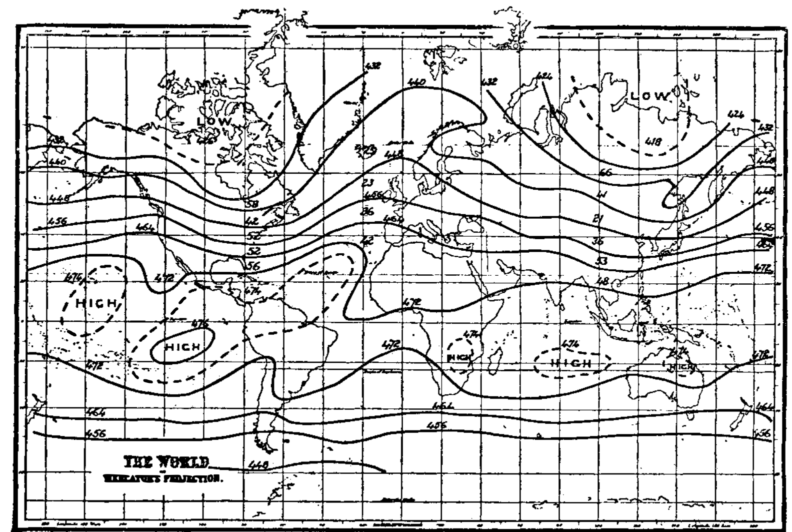


FIG. 1.—SURFACE ISOBARS FOR JANUARY.

Reproduced from Hann's "Meteorologie."



Pressures in millimetres: velocities in miles per hour, corresponding to the acceleration for different gradients resulting from the Earth's rotation.

FIG. 2.—ISOBARS AT THE LEVEL OF 4,000 METERS FOR JANUARY.

From Hann's reproduction of the original diagram by Teisserenc de Bort.

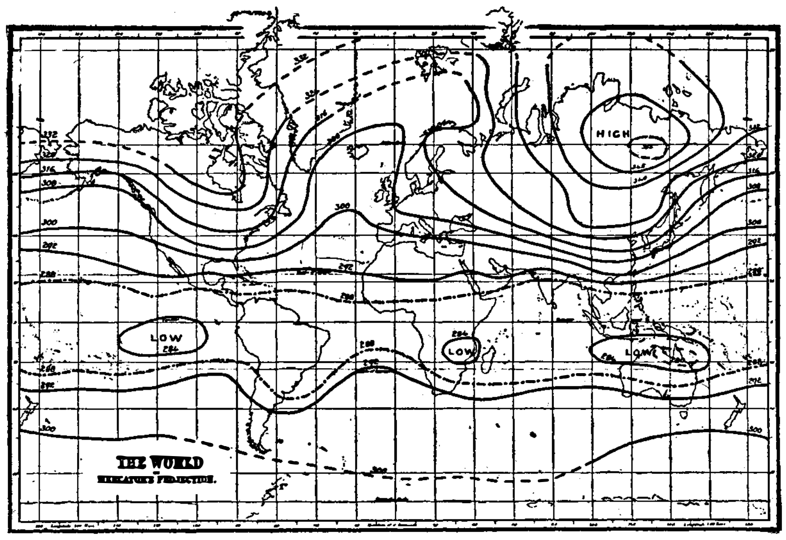


FIG. 3.—MEAN PRESSURE DUE TO THE WEIGHT OF THE STRATUM OF THE ATMOSPHERE BELOW 4,000 METERS.

For the month of January. Computed from Figs. 1 and 2. Pressures are given in millimeters.

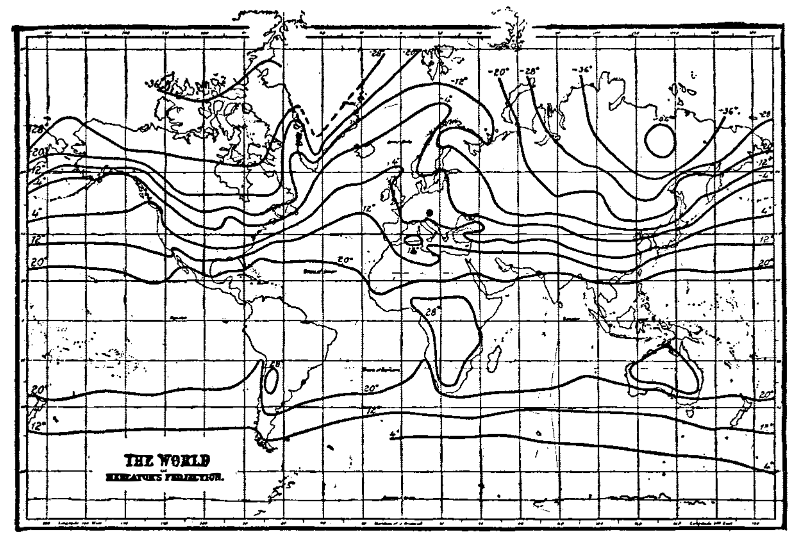


FIG. 4.—MEAN TEMPERATURE AT THE EARTH'S SURFACE.

For the month of January. In Centigrade degrees.

So much for the upper air; the motion is comparatively simple. Then it might be supposed that the complexity of the surface motion is due to extreme complexity of pressure in the lower stratum. The pressure due to the weight of the lower stratum is shown in Fig. 3, which gives the pressure differences between Figs. 1 and 2. There is, strange to say, no more complexity about this distribution than there is about the pressure of the upper layer; in fact, the lines of the two are extraordinarily similar, only the pressure gradients run in opposite directions. Writing "high" for "low," the one diagram would not be an unsatisfactory duplicate of the other, except that the lower stratum has a dislocation of the pole of high pressure from the geographical pole to northeastern Siberia. Applying the same principle of motion to this diagram as to Fig. 2, it would represent, with suitable velocities calculated in a similar manner, a circulation from east to west in each hemisphere round the pole of cold.

Compare both these diagrams with Fig. 4, representing the surface isothermal lines—the similarity is again conspicuous. The intervals are for every 8 deg. C. of temperature instead of 8 millimeters of pressure, and speaking broadly of the temperate latitudes, starting from a suitable datum temperature or pressure, the lines might be interchanged, a step of one degree

* Based upon a paper on the "General Circulation of the Atmosphere in Middle and Higher Latitudes," read before the Royal Society on June 2 by Dr. W. N. Shaw, F.R.S.

of temperature (Fig. 4) corresponding to a step of one millimeter of pressure in the same direction for the upper layer (Fig. 2), and in the opposite direction for the lower layer (Fig. 3).

The complexity of the surface pressure arises, therefore, not from the upper layer alone, nor from the lower layer alone, but from the superposition of the two. We can resolve the surface pressure into two components, one due to the upper stratum above 4,000 meters, which, if it acted alone, would produce a general circulation from west to east around minima of pressure near the poles; the other, due to the lower stratum, which, if it acted alone, would produce a circulation from east to west. Both circulations would correspond closely with the surface distribution of isotherms. Where the one is predominant, in the lower middle latitudes, we get resultant westerly circulation; where the other is predominant. near the poles of cold, we get an easterly circulation. Between the two we get a region of minimum pressure and a merging of the two circulations which gives rise to the circular storms of the northern and southern temperate zones.

It appears, therefore, that we ought to regard the surface distribution of temperature as giving rise to a distribution of pressure in the lower stratum tending to maintain a circulation of air from east to west round the poles of cold. Extending this idea, a region of cold in the northern hemisphere should tend to maintain a clockwise circulation round its center in the lower atmosphere, and a region of heat a counter-clockwise circulation.

The reciprocity between the pressure distribution of the upper and lower layers is of course not fortuitous. Hann has shown that the expansion of the lower layer by heat increases the pressure at a given level in the upper regions, without altering the pressure at the surface, by the mere thrusting of part of the air upward; so that the observed effect of expansion over a large area is to diminish the pressure of the lower stratum and increase, by an equal amount, that of the upper. Referring to the diagrams again, the effect of increased surface temperature upon the isobars of Fig. 3 would be a bulge of the isobars toward the region of low pressure—the equatorial regions; upon the upper isobars there would be a corresponding bulge toward the region of higher pressure, again the equatorial regions. Thus the lines of both diagrams would be affected geographically in an exactly similar way and to the same extent; they would thus preserve their similarity in spite of temperature variations at the surface.

It would be interesting to consider what the effect of the daily solarization of the earth should be from this point of view. Primarily it should produce no pressure variation at the surface; but inequalities of motion in the upper and lower air would probably alter the relative phase or magnitude of the disturbance of the two components, and hence give rise to daily variations of pressure at the surface, and thus necessarily produce a diurnal variation of the barometer.

Other consequences follow from the treatment of the distribution of pressure due to the weight of the lower layer as producing, or rather maintaining, a circulation in the one direction or the other about the colder or warmer regions, as the case may be, instead of flow from cold regions to hot.

One important result as regards the formation of circular storms in our latitudes may be inferred from this method of analyzing the distribution of surface pressure. Friends have frequently suggested to me that our circular storms are like the eddies formed when water flows through a bridge; and to them I have always put the question, What in the atmosphere stands for the bridge? I am now prepared to recognize that the caps of relatively cold air in the north and south polar regions form an adequate representation of the piers of the bridge. In the lower air, where the pressures of the polar caps are dominant, they stop the westerly currents which still flow in lower latitudes, and replace them by currents from the east. Between these two currents is a field where mixing must take place, and circular eddies may be formed.

What happens in the equatorial regions is another story. Buys Ballot's law shows that the equator is subject to a peculiar meteorological condition. If you stand with your back to the wind north of the equator, the low barometer is on your left; south of the equator, it is on your right. There must be a transition region where the law ceases to apply, as, indeed, one would expect if Buys Ballot's law is the practical expression of motion with an acceleration due to the rotation of the earth, and varying as the sine of the latitude.

In the upper air of the equatorial regions there is probably a persistent flow from the east, as shown by observations of clouds and of the Krakatoa dust. In respect of the formation of eddies, this current will act like an intermediate pier of a bridge. Hence, in January, the river in which, upon this analogy, atmospheric eddies may be expected is a stream of air flowing round the earth in middle latitudes, divided by the equatorial belt with its region of doldrums below and easterly current above, and bounded north and south by easterly currents which correspond with the circulation of the lower atmosphere induced by the predominant influence of the polar caps of cold air. Eddies may be looked for between the easterly and westerly currents, and they are sometimes found there.—W. N. Shaw, in Nature.

THE RADIATION AND EMANATION OF RADIUM.*

By E. RUTHERFORD, M.A., D.Sc., F.R.S., Macdonald Professor of Physics, McGill University, Montreal.

SCARCELY more than seven years have elapsed since Becquerel discovered that uranium possesses the property of spontaneously emitting radiations, capable of passing through substances opaque to light, of acting on a photographic plate, and of discharging

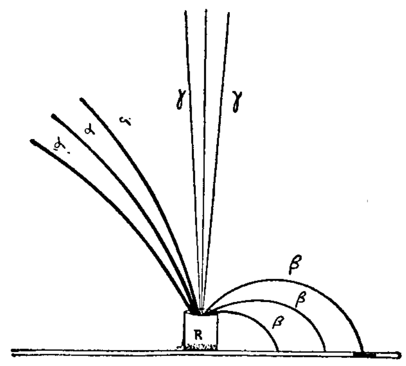


FIG. 1.

electrified bodies. Nevertheless our knowledge of the subject has grown with surprising rapidity, and a very large amount of information has now been collected, not only concerning the radiations from the radio-active bodies, but also the complicated processes occurring in them. A theory has also been advanced which serves to connect in an intelligible manner the remarkable series of phenomena observed.

Soon after Becquerel's discovery of the radio-active properties of uranium, the rare element thorium was found to be radio-active. An examination of the mineral pitchblende has revealed the presence of a series of new radio-active bodies, which possess the property of radio-activity to a very intense degree compared with uranium and thorium. Of these bodies, the substance *actinium*, discovered by Debierne, will probably prove to be a new element of activity comparable with that of radium, while the radio-active elements present in the *polonium*, discovered by Mme. Curie, and the *radio-tellurium*, discovered by Marckwald, have not yet been chemically isolated. The substance *radium*, discovered in 1898 by M. and Mme. Curie in pitchblende, has attracted the greatest amount of attention, partly on account of the fact that it has been found to be a new element with a definite spectrum and atomic weight; but chiefly on account of its surprising radio-active properties; for its radiations are nearly two million times as intense as those emitted from an equal weight of uranium.

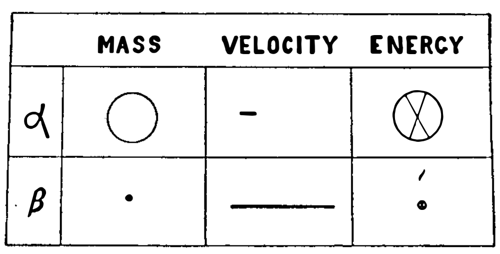


FIG. 2.

The velocity is represented by the length of a line and the mass and energy by spheres.

Much of our present knowledge of radio-activity has been derived from a study of the comparatively feeble radio-active bodies, uranium and thorium. The radio-active properties of thorium are qualitatively similar to those of radium, but differ very widely in intensity. In this article, for brevity, the properties of radium alone will be considered, although the explanation advanced for radium in many cases applies also to the other radio-active bodies.

The characteristic radiations from radium are invisible to the eye, but are, in part, transformed into light when they fall on certain fluorescent substances. An ordinary X-ray screen of barium platino-cyanide is rendered luminous in a dark room when the rays from radium fall upon it. The mineral willemite (zinc silicate) lights up brightly under the rays from a few milligrammes of radium bromide; it appears quite

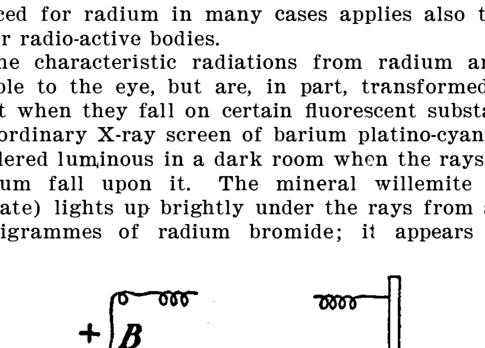


FIG. 3.

translucent, emitting light of a beautiful greenish color. Another mineral, kunzite, exhibits a beautiful rose coloration under the rays, but the intensity is not so marked as in the case of willemite or crystals of the platino-cyanides.

The radiations from radium are very complex in character, and comprise three kinds of rays, called the α, β and γ rays. The greater part of the rays emitted bear no resemblance to ordinary light waves, but consist of flights of material particles projected with enormous velocity. The nature of the β rays was first determined, on account of the ease with which they are deflected by a magnet. If a small quantity of radium bromide is placed at the base of a small lead cylinder, the cone of rays issuing from the open end produces a luminous patch on a willemite or X-ray screen brought near it. The luminosity observed is mainly due to the β rays. On bringing up a magnet near the radium, the light patch is observed to be deflected and also to be greatly broadened. By reversal of the magnet, the direction of movement is reversed. The broadening of the cone of rays in a magnetic field shows that the rays emitted are complex in character, some of them being more readily deflected by a magnetic field than others. In a similar way, it has been found that the rays are deflected in passing between two parallel plates kept charged to a high difference of potential by an electric machine. In these and other respects, the β rays are identical with the rays which are shot off from the cathode when a strong electric discharge is passed through a vacuum tube.

By measuring the amount of deflection of the cathode rays, in passing through both a magnetic and electric field of known strength, J. J. Thomson has shown that they consist of a flight of particles, carrying negative charges of electricity, and projected with a velocity of about 50,000 miles a second. The particle shot off from the cathode is the smallest body known to science, for

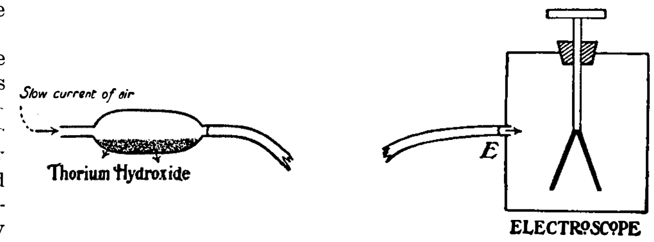


FIG. 4.

apparently its mass is only about 1-1000 of that of the hydrogen atom. The β particle shot out from radium is identical in size with the cathode ray particle, but is projected with a much greater average speed. Kaufmann has shown that some of the particles possess an initial velocity of over 170,000 miles per second, i. e., a velocity very nearly equal to that of light.

The γ rays from radium are of an extraordinarily penetrating character, for their presence can readily be detected through several inches of lead or a foot of iron. They are not deflected by a magnetic or electric field, and there is now little doubt that they are a type of very penetrating Röntgen rays. According to the views of Stokes and J. J. Thomson Röntgen rays are very short transverse waves or pulses in the ether, which are set up when the cathode ray particle is suddenly stopped by striking an obstacle. It is to be expected that Röntgen rays should be set up at the sudden starting as well as at the sudden stopping of a charged particle, and the present evidence points to the conclusion that the γ rays arise at the moment of the expulsion of the β particle from the radium atom. Thus, unlike the β rays, the γ rays are not corpuscular

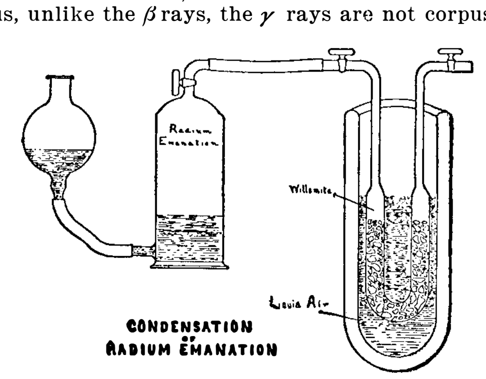


FIG. 5.

in character, but are more akin to very short light waves.

The α rays have very slight penetrating power and are absorbed in their passage through a few centimeters of air or by a sheet of paper. They were for a long time thought to be incapable of deflection by a magnetic or electric field; but in 1902, the writer found that they could be bent from their path by the application of a very intense magnetic or electric field. The direction of deflection was, however, opposite to that observed for the β rays, which showed that the α rays carried with them, not a negative, but a positive charge of electricity. By observing the amount of bending of the rays in passing through a magnetic and an electric field of known strengths, it was deduced that the α particles are projected with a velocity of about 20,000 miles a second, and have a mass about twice that of the hydrogen atom. If the α particles consist of any known kind of matter, these measurements pointed to the conclusion that they were either hydrogen or helium atoms, for next to hydrogen, helium has the lightest atom known to science. The significance of this result is seen in the light of the production of helium from radium, which will be considered later.

The fundamental phenomenon of radio-activity consists in this continuous and spontaneous expulsion from radium of heavy particles of matter atomic in size, with enormous velocity. Each particle has a velocity about

* Technics.

40,000 times as great as a rifle bullet, so that its energy of motion is enormous compared with the mass of the body in motion.

The rays from radium are very similar to those produced when a strong electric discharge is sent through a vacuum tube. The β rays are like the cathode rays, the γ rays are similar to the Röntgen rays, while the α rays are very analogous to the "canal" rays discovered by Goldstein. In order to produce these rays in a vacuum tube, a large expenditure of electric energy is required. Radium, on the other hand, gives them out spontaneously, without, so far as is known, the action of any external exciting cause.

The effect of a magnetic field in separating out the rays of radium is shown diagrammatically in Fig. 1. The radium R is placed in a small lead vessel, and the α, β and γ rays are projected as a cone of rays from the opening. On applying a magnetic field at right angles to the plane of the paper, and in a direction downward through the paper, the β rays are bent to the right, the α rays to the left, while the γ rays are not bent at all. The amount of bending of the α compared with the β rays, is very much exaggerated in the figure.

The comparative size, velocity, and energy of motion of the α and β particles are shown graphically in Fig. 2.

The energy of motion of the α particle is much greater than that of the β particle. There is, in addition, evidence to show that four α particles are projected for every β particle, so that nearly all the energy emitted from radium, in the form of rays, is carried off by the α particles. Not only are the α particles of more importance from the point of view of emission of energy, but they also play a far more important part in the complicated processes which occur in the radium atom. It can be calculated that every gramme of radium projects about one hundred thousand million α particles per second, and yet there is such an enormous number of atoms in a gramme of matter that the process could continue for years before an appreciable proportion of the matter had been fired away.

The rate of expulsion of the α or β particles is not appreciably influenced by any physical or chemical agency under our control. At the temperature of liquid air, it proceeds at the same rate as at a red heat.

The continuous expulsion of α particles from radium is very well illustrated by a beautiful experiment devised by Sir William Crookes. If a trace of radium is brought near to a zinc sulphide screen, the surface of the screen is rendered luminous by the α rays. On examining the screen with a magnifying glass, the luminosity is found to lack uniformity, consisting of a multitude of sparks of light coming and going with great rapidity. The action brings vividly before the observer the idea that the screen is subjected to an intense bombardment, the impact of every projectile as it strikes the target being marked by a flash of light. The massive α particles have such an enormous energy of motion, compared with their size, that they produce, at impact, an alteration in the crystals of zinc sulphide —probably a cleavage—which is accompanied by a flash of light.

The most important property possessed by the radiations from the radio-active bodies is that of discharging electrified bodies. This property has been utilized as a means of accurate measurement of the radiations, and is by far the most delicate method of detecting the property of radio-activity in bodies. If radium exists in a gramme of inactive matter, only to the extent of one part in ten thousand million, its presence can readily be detected by its power of discharging a gold leaf electroscope. This discharging action of the rays is due to the production of positively and negatively charged particles, or ions, as they are termed, in the electrically neutral gas through which the radiations pass. The α and β particles have such a large energy of motion that they produce ions by collision with the gas molecules in their path; each projected particle is capable of producing many thousands of ions before its energy is dissipated. These ions travel in the electric field and cause the loss of charge observed.

If a trace of radium bromide is placed on a plate A (see Fig. 3) near a plate B, connected metallically with a charged gold leaf electroscope E, the charge is very rapidly dissipated, and the leaves L rapidly collapse. Most of this discharging action is due to the α rays. If a sheet of paper is placed over the radium, the α rays are almost completely intercepted by it, and the discharging action is then due to the β and γ rays. If the radium is completely covered with a lead screen about 5 millimeters thick, the β rays are almost all stopped, and the discharge in the electroscope is thus caused by the action of the γ rays alone. Speaking generally, the α rays are far more effective in causing discharge, and producing luminosity in bodies, than the more penetrating β and γ rays. On the other hand, the β rays are the most active in darkening a photographic plate.

Curie and Laborde recently showed that radium possesses the striking property of continuously keeping itself at a temperature of 4 deg. or 5 deg. F. above the surrounding air. This shows that radium, in addition to its radiations, continuously emits energy in the form of heat. The amount of heat from 1 gramme of radium corresponds to about 100 gramme-calories per hour. A pound of radium would emit per year about as much heat as is given out by the combustion of one hundred pounds of coal. This is a very remarkable result, for at the end of a year the radium shows no apparent sign of alteration, and still continues to give out heat at an undiminished rate. The rate of heat emission has been shown, by Curie and Dewar, to be unaltered when the radium is kept at the temperature of liquid hydrogen.

This emission of heat is, in reality, directly connected with the radio-activity of radium, and is not an independent phenomenon. There is little doubt that the heat emission is a direct consequence of the continuous expulsion of α particles from the radium. The α particles are readily absorbed in their passage through matter; and in a pellet of radium, only a small percentage of the total number emitted are able to escape into the surrounding gas. The rest are absorbed in the mass of the radium itself. The radium is thus subjected to an intense and continuous bombardment by the α particles projected from its own mass. Just as a target is heated by the impact of bullets upon it, so the radium becomes hot in consequence of its self-bombardment. A part also of the heat emitted probably results from the explosion in the atom, which results in the ejection of the α particle.

Not content with emitting three kinds of rays and continuously giving off heat at a rapid rate, radium also produces from itself a radio-active "emanation" or gas. This emanation is produced in minute quantity; but compared with the amount of matter, is an extraordinarily powerful radiator of energy. This property of giving off an emanation was first observed by the writer in the radio-active element thorium. If a slow current of air is passed through a tube T (Fig. 4) containing some powdered thorium oxide, or still better, thorium hydroxide; and is then passed through several yards of tubing opening into the electroscope E, the gold leaves of the electroscope are observed to rapidly collapse. The emanation, mixed with the air, is conveyed into the electroscope, and the radiation from it ionizes the gas and causes the collapse of the leaves. If the current of air is stopped, the rate of discharge rapidly decreases with the time, falling to half value in an interval of one minute. If a radium solution is substituted for the thorium, a similar action is observed; but on account of the enormous activity of radium, the effects are far more intense. The emanation obtained from one-millionth of a gramme of radium bromide causes the leaves to collapse in a few seconds, while the emanation from one ten-thousand-millionth of a gramme is readily measurable. This property of radium, of giving off an emanation, affords the most delicate and certain method of detection and estimation of minute quantities of radium. The emanation of thorium is very readily distinguished from that of radium, on account of the slow loss of activity of the latter. The radiating power of the emanation of radium falls to half value in four days, and is still appreciable after it has been stored up in a closed vessel for a month.

The emanations of thorium and radium have been the subject of a large amount of investigation. They have been shown to diffuse through air like heavy gases, and to be unacted on by any known chemical reagents. Mr. Soddy and the writer found that the emanations of thorium and radium could be condensed, like gases, by the action of extreme cold. The thorium emanation condenses at —120 deg. C., and the radium emanation at —150 deg. C. With a large amount of radium emanation, the process of condensation can be followed by the eye. A simple experiment for this purpose is shown in Fig. 5. A quantity of emanation is collected in the small gasometer by bubbling air through a radium solution. The emanation, mixed with air, is then passed through a glass U tube, immersed in liquid air contained in a Dewar flask. In order to show the presence of the emanation, the U tube is partly filled with small pieces of willemite. As the emanation is slowly carried into the U tube, it condenses at the point of the tube just below the surface of the liquid air. The radiations from the condensed emanation render the willemite luminous; and, with a considerable quantity of emanation, the luminosity is very brilliant. With a very slow current of air, the luminosity is concentrated at the portion of the U tube where the air enters, while the rest of the tube is not luminous at all. On closing the ends of the tube and removing it from the liquid air, the emanation volatilizes as soon as the temperature rises above —150 deg. C., and the whole tube becomes luminous. The light from the tube slowly diminishes, as the inclosed emanation loses its activity, but is still appreciable after a month's interval.

If the emanation, after being allowed to remain in the U tube for several hours, is blown out by a current of air, the luminosity of the willemite does not at once disappear, but continues for several hours. This continued luminosity is due to a remarkable property possessed by the emanation of manufacturing from itself a new kind of radio-active matter which is not gaseous, but behaves like a solid, and is deposited on the surface of bodies. A body which has been exposed some time in the presence of the emanation, behaves as if it were covered with an invisible film of intensely radio-active matter. This deposit is soluble in acids, is driven off at a white heat, and generally acts like a substance with definite chemical properties. The deposited matter continues to radiate for several hours. This power of "exciting" or "inducing" activity in neighboring bodies is possessed by the emanations of both thorium and radium. The excited activity produced by the thorium lasts much longer than that produced by the radium emanation, and is appreciable several days after the emanation has been removed.

If the tube in which the radium emanation is stored is filled with layers of different substances which are rendered luminous by the rays, the differences in color and intensity of the luminosity can be very clearly seen. Willemite shines with a beautiful green color, and kunzite with a dark red color. Zinc sulphide shows a white luminosity. Crystals of barium platinocyanide are at first as luminous as willemite; but the color and luminosity of the crystals rapidly change, due to a chemical action of the rays upon them. The luminosity of willemite and zinc sulphide is mostly due to α rays, while kunzite is more sensitive to the β and γ rays.

A tube containing the radium emanation has temporarily all the properties of radium. It gives out β and γ rays, and also emits heat at a rapid rate. The emanation, when collected in a concentrated form, is luminous in the dark and causes glass to phosphoresce. It rapidly blackens the walls of the glass tube containing it, and is able to produce marked chemical action in some substances. If collected over water, it manufactures hydrogen and oxygen at a rapid rate. All these effects are produced by an extraordinarily small amount of the emanation. Sir William Ramsay and Mr. Soddy have recently succeeded in isolating the emanation from radium, and in determining its volume. They calculated that one gramme of radium contains about one cubic millimeter of the emanation, when measured at atmospheric pressure and temperature. The emanation has all the ordinary properties of a gas. It has a definite spectrum, but it differs from all other gases, inasmuch as its volume diminishes with time; it is not permanent, but is continuously changing into a solid substance, which is deposited on the walls of the containing vessel. But the most remarkable feature of the emanation is its enormous power of radiating compared with its weight. Dr. Barnes and the writer recently showed that three-quarters of the total heating effect of radium is due to the small amount of emanation stored up in it. The emanation was removed from the radium by heating it, and then collected by condensation in a small glass tube immersed in liquid air. The tube containing the emanation glowed in the dark and gave off heat at a rapid rate, while the radium from which the emanation was separated lost three parts of its heating effect. The emanation lost its heating effect at the same rate as it loses its activity, i. e., the heating effect diminished to half value in four days, and had nearly disappeared in the course of a month. The radium at the same time spontaneously regained its power of heat emission, and after a month's interval gave out heat at the same rate as before the experiment. Not only does the emanation itself give out heat, but the matter which is deposited from it on the walls of the vessel does so also. The heating effect was found to depend upon the emission of α particles, and is directly connected with the radio-activity. The greater portion of the heating effect of the emanation is due to the continuous bombardment of the walls of the tube and the contained gas by the α particles, which are thrown off by the emanation, and the other substances which are produced from it. If one cubic inch of the emanation were collected, the heat energy from it would be sufficient to melt down the walls of the glass tube containing it. It can readily be deduced that, weight for weight, the emanation emits about a million times more energy than that produced in the most violent chemical reaction. A pound weight of the emanation, immediately after its separation, would give out energy at a rate of about 10,000 horse-power. The rate of emission of energy would decrease to half value in four days, and would be appreciable after a month's interval; but the emanation, during the time its activity lasts, would give out an amount of energy equivalent to an engine working at 10,000 horse-power for six days. If it should ever be possible to obtain a large quantity of this emanation and to utilize its energy, a few pounds of it would suffice to provide enough power to drive a liner across the Atlantic. As it would probably require about fifty tons of radium to produce one pound of emanation, the outlook for the utilization of the emanation as a source of power is not at present very promising.

(To be continued.)

Heavy Ions.—Several attempts have been made to explain the fact, observed by W. Wien, that the positive ions constituting canal rays have a continuously varying deflection under the influence of a magnetic field. This might be supposed to be due to the subdivision of the electron, or the formation of larger molecular aggregates having a single positive elementary charge each. To avoid either of these suppositions, Stark supposed that positive ions were neutralized at various points along their paths by taking up a negative electron, and, since such neutralization would withdraw them from any further action of the magnetic field, the magnetic spectrum produced would be a continuous one. Now, W. Wien has found an experimental method of testing these various hypotheses, and the results lead him, on the whole, to decide in favor of the large molecular aggregates. He employs a wide tube with several protected electrodes, one of which lies directly in the path of the canal rays, while another lies in the path of a portion of the deflected beam. If Stark's hypothesis were correct, then, on establishing the magnetic field, the charge received by the first electrode should be reduced to zero, since none but neutralized molecules would be able to reach it. It is found, however, that even in the strongest magnetic field the charge cannot be reduced below one-fifth of the original amount. This cannot be attributed to diffusion, since the other protected electrodes under ordinary circumstances never receive more than 1 per cent of the charge. The author proceeds to draw some interesting conclusions from the deflections observed in hydrogen in certain fields. The ratio e/m comes out as 15.5 instead of 10,000, as in the electro-chemical hydrogen ion. Regarding this as a new molecule, its molecular weight would be 650, which is heavier than the molecule of any known substance, though still of the order

of known molecular weights. It is to be supposed, however, that these heavy ions are in an unstable condition, and break up on impinging upon the glass wall.—W. Wien, Ann. der Physik., No. 4, 1904.

ENGINEERING NOTES.

While coal mining in Pennsylvania has not yet required such deep shafts as those in England or Belgium, there are several which approach 1,800 feet in vertical depth.

Petroleum engines for pumping water from wells for the purpose of watering the orange gardens of Jaffa have been greatly used during the last three years; their introduction into the country is due to the Germans, who sold about eighty of them. The British market followed, and sold about the same number up to the end of last year.

Soft carbon steel plates and tubes become permanently contracted when heated and cooled frequently, and it has been found that a 25 per cent nickel steel tube, when heated to a dull red, showed a greater expansion than the mild carbon steel tube. Further experiments have shown, however, that the alloy containing between 30 and 40 per cent nickel is less susceptible to this expansion. The nickel steel tube also exerts a greater resistance to corrosion, possesses greater tensile strength, and any elongation due to expansion in service is distributed equally over its entire length, whereas the soft carbon steel generally elongates locally.

The Sargent anglemeter is designed to indicate the variation of the angular velocity of the crank-shafts of steam engines during a revolution. It consists of an ordinary balance gear such as that used on motor cars and tricycles, one of the main bevel-wheels being driven from the engine-shaft through an inextensible belt and a light driving pulley, and the other being rigidly connected to a heavy flywheel. The transverse axis bearing the intermediate bevel-wheel is prevented by means of springs from rotating about the main axis, and is connected to a pointer. The flywheel and main bevel-wheel connected thereto, since they are driven through the spring-supported intermediate bevel-wheel, rotate at a practically constant velocity, and thus serve as a standard. As the velocity of the other main bevel-wheel varies, the position of the intermediate bevel-wheel changes, the amount of variation being indicated on a dial by the pointer. The original paper is fully illustrated.

F. Glaser has conducted some interesting experiments on latent heat and specific heat of metals of high temperatures. The method of mixtures is used. The calorimeter had a capacity of 40 liters. The heating chamber, as in Regnault's apparatus, was placed above it, and consisted of a resistance electrical furnace. In the central space a rod of gas carbon 2 millimeters thick was heated by a current passing from a carbon block at the bottom to another carbon block at the top of the chamber. A uniform temperature was thus maintained, and the atmosphere within the chamber contained gas which would prevent oxidation of the metals used in the experiments. From observations at different temperatures the specific heat at the melting-point was found by extrapolation, and then, from the apparent specific heat of the molten substance, the latent heat was deduced. From the details of the observations the following table has been compiled:

Metal.	Specific Heat at Melting-point.	Melting-point.	Latent Heat.
Lead	0.0324	326 deg. C	4.78
Zinc	0.1066	415	29.86
Aluminium	0.2745	657	76.80
Copper	0.1172	1084	41.63
Tin	0.0552	228	13.62

The furnace temperatures were measured by a Le Chatelier thermo-element and a Siemens and Halske galvanometer.

Most of the Continental tramways are using steel-tired wheels, whereas, till recently, the general practice has been to use chilled-iron wheels. In explanation of this it should be stated that the full-grooved rail is almost universally adopted, and the grooves are much narrower than those in the United States. As it is very difficult to make a chilled-iron flange with any depth of chill to fit these narrow grooves and yet provide it with a backing of gray iron, chilled-iron wheels in Europe have in many cases chipped badly on the flange. A table gives some recent quotations of the cost of cast-iron, steel-tired, and cast-steel wheels as used in different cities, principally on the Continent. Experience has proved that cast steel will give enough longer life to warrant its increased first cost over the forged-iron centers. The article concludes with extracts from some steel-tired wheel specifications prepared by Fell for the Sheffield Corporation Tramways. As these specifications are the result of a number of tests, they are of the first importance: Centers.—The centers to be 26¾ inches diameter, to be of cast steel, having a tensile strength of from 30 to 35 tons per square inch, and an elongation of at least 15 per cent in 2 inches. They must be capable of withstanding a test load, applied by static pressure to the center, of at least 50 tons, without producing any permanent set, and also a load of at least 100 tons applied in the same manner, without showing signs of breaking up. The above loads to be applied to the hub of the wheel in a testing machine, the rim resting against four bearing blocks, about 3 inches wide, fixed on the stationary portion of the machine. The whole of the centers to be carefully turned and stepped on the rim for the reception of the tires. The hub to be faced on both sides of the wheel and bored for the axles. The weight of the finished center not to be less than 164 pounds. Tires.—The tires to be of specially tough, rolled crucible or Siemens-Martin steel, having a tensile strength of from 50 to 55 tons per square inch, with a minimum elongation of 11 per cent to 8 per cent in 2 inches. The tires to be shrunk on the wheel centers, and secured to the same by an approved method, so that it will be impossible for the tire to work loose sideways, or circumferentially. The weight of finished tire to be not less than 166 pounds. Mileage.—Every tire must run at least 5,000 miles per ⅛-inch thickness without breaking the flange, loosening, or showing any other signs of defect down to a minimum thickness of ¾ inch.—Street Ry. Jour.

TRADE NOTES AND RECIPES.

To Exterminate Colonies of Ants.—While the nests are superficial, as in the case with the small red ant, boiling water in plenty is usually sufficient. With the small black ant of the Gulf coast, and the large black or soldier ant the case is different. With these use a weak solution of mercury bichloride.—Nat. Drug.

Nickel-Aluminium Alloys.—Nickel-aluminium alloys could until lately only be produced in the proportion of 2 per cent of aluminium. The fusing point of nickel is about 1,450 deg. C., while aluminium melts at near 600 deg. The great obstacle is this enormous difference between the fusing points of the two metals. A new process, which consists in utilizing copper as an intermedium to unite them, makes it possible to produce this alloy in other properties. Aluminium is first mixed with copper, then nickel added. The product obtained in this way, the greatest part of which is aluminium, has been called *minickin*. Its density is 2.86. It resembles palladium; weak acids do not act upon it, and its resistance to rupture is very great.—Translated from Le Cosmos.

To Fit Red Wine Casks to Receive White Wine.—Wine dealers will doubtless be pleased to learn of a cheap, simple process, attended with little or no trouble, whereby the red coloring of red wine may be so completely removed from the walls of casks that white wine must may be safely stored in them, and if necessity require, old white wine may also be conveyed into them without fear of discoloration.

We are indebted to the Deutsche Destillateuren Zeitung for the following: Strong mineral acids neutralize readily, when warmed, the coloring matter of red wine. Thin down ¼ liter of crude hydrochloric acid with 10 liters of boiling water. This is sufficient for a cask containing 100 liters. For a cask containing 600 liters, 60 liters of boiling water and 1½ liters of crude hydrochloric acid would therefore be required. With this solution inside, roll or revolve the cask from 15 to 30 minutes, then let off the highly-colored decoction, rinse out with clear water, and, in order to remove the pickle from the cask, treat it with a boiling solution of 2 kilogrammes of soda to 100 liters of water.

Having run off the soda decoction, fill the cask completely full of cold water and let it stand thus for several days.

To ascertain whether the color has been sufficiently removed, chip off a splinter from the interior of the wine cask and observe the color of the cut surface. If red coloring matter is still discernible the above operation must of necessity be repeated. As a rule, however, one turn has thus far sufficed.

Cheap, Deep Black Writing Ink.—Boil 50 parts of logwood chips in 500 parts of water, to extraction. Let cool off, then add and dissolve 5 parts of yellow potassium chromate. This ink is at first a deep violet, but the writing soon becomes deep, intense black. Do not add either sugar or gum, as they detract from the value of the ink. If on standing this ink thickens up, disolve a little corrosive sublimate in water and add to it, drop by drop, until the tendency disappears.

The following makes also a cheap deep black ink: Dissolve 10 parts of best French extract of logwood in 500 parts of water, by the aid of gentle heat. Set this solution aside for a week, then carefully decant the clear fluid. To every 200 parts of this stock solution add 500 parts of water, place in a water-bath and bring up nearly, but not quite, to a boil (about 195 deg. F.). Dissolve 2 parts of potassium dichromate, 50 parts of chrome alum and 10 parts of oxalic acid in 150 parts of water by the aid of heat, and add the solution to the foregoing. This must be added little by little, very slowly and carefully, with constant stirring. Continue the heating for half an hour, keeping the liquid just below the boiling point. Finally, add sufficient water to make the whole up to 1,000 parts, and 10 parts of carbolic acid. Set aside for two or three days, then decant the clear part and put into bottles for use.

Finally, we give you a formula for the old iron and gall nut ink, as follows:

Aleppo gall nuts, bruised	12 parts
Water	48 parts

Boil together in a copper vessel for 1 hour, adding hot water from time to time to make up for that lost by evaporation. Strain off the liquid and set aside close to a fire so it will keep hot. Add to residual nuts 32 parts of hot water and boil for 30 minutes longer, strain off and add the liquid to the first colate. Finally, add 20 parts of hot water and boil the nuts for another half hour, strain and add to the other colates. While the assembled liquids are still hot, add 4 parts of iron sulphate in coarse powder and 3½ parts gum arabic, also in coarse powder, and stir till dissolved. Let stand over night, strain through a hair sieve and bottle for use.—Nat. Drug.

ELECTRICAL NOTES.

Referring to the old methods of predetermining the sparking in continuous-current machines, and to the later development consisting in taking the reactance voltage as a criterion for the sparking, W. L. Waters (Amer. Inst. Elect. Eng.) gives a description of all the factors influencing the sparking, beyond those comprised in the reactance voltage formula. He introduces an "inequality factor" depending upon the use of several segments per slot. For instance, in a motor with twenty slots per pole, three segments per slot, pole face = 75 per cent of pole pitch, the writer finds his "inequality factor" to be 1.26, i. e., the reactance voltage may be taken 1.26 times higher in a motor with one segment per slot than in the motor under consideration. In the same way the inequality introduced by using a dead coil in the armature may be estimated.

A description of a method recently patented by J. N. Alsop for the electrical treatment of flour is given in Western Electrician. It is known that certain gases are able to bleach and purify flour. The gaseous mixture produced by the electric arc in air is found to be very effective in this respect. It contains nitrogen peroxide and traces of ozone and is ionized. Chemical analyses of the treated flour show that there is a combination of a relatively large amount of nitrogen with the flour. The bleaching of the flour is effected without destroying any essential qualities. It is further claimed that bread made from the treated flour is more nutritive. The apparatus for producing the gas consists of two arc lamps in parallel. The lower carbons are fixed, but the upper carbons are movable, being attached to the ends of a balance beam so that when one carbon is in contact with its lower carbon the other carbon is some distance away from its carbon. By using a coil with considerable self-induction, an arc as long as 18 inches can be produced before the arc is extinguished. The arcs are surrounded by tubes, from the bottom of which the gas is drawn off and passed into a revolving hexagonal drum where it is thoroughly incorporated with the flour.

N. A. Dubois gives instructions for the preparation of allotropic silver films for electrical purposes. A mixture of 200 cubic centimeters of a 30 per cent solution of ferrous sulphate and 280 cubic centimeters of a 40 per cent solution of sodium citrate is treated with a 10 per cent solution of caustic soda, just till no permanent precipitate is formed. This is then mixed with 200 cubic centimeters of a 10 per cent silver nitrate solution, stirred thoroughly, allowed to settle and the liquid decanted. The precipitated allotropic silver is treated with about 200 cubic centimeters of distilled water, which dissolves a part of it, and is again precipitated by treatment with a saturated solution of ammonium nitrate. This process is repeated three times, and the final precipitate filtered with suction and washed with 95 per cent alcohol. The product is transferred, in the form of a brown mud, to a bottle and kept covered with alcohol. The emulsion spread on any surface and dried gives a copper-colored film. When these films are treated with gaseous hydrochloric acid from a reversed wash-bottle they are immediately changed to ordinary silver, and present a dull silvery appearance, which is changed to bright silver by slight friction and is highly conducting.

It is known since the work of Hittorf and Goldstein, that when the cathode is brought to a white heat, the cathode fall of potential—i. e., the difference of potential traversed by an ion in emerging from the cathode into space surrounding it—practically disappears, but that no such effect is produced by the heating of the anode. A. Wehnelt has further studied this effect, especially in connection with the extraordinarily strong effect exhibited by certain oxide cathodes. These are the oxides of the alkaline earths, while magnesium, zinc and cadmium show a feebler effect, and other metals, such as sodium or mercury, owe their apparent effect to secondary causes. The quantitative measurements made by the author show that there is a profound influence of the pressure upon the sign and the amount of the ions emerging from the cathode. At atmospheric pressure, even at a dark red heat, there are more negative than positive ions given out by electrodes of the oxides of calcium, strontium and barium, whereas in the case of platinum the positive ions are in the majority, even at very high temperatures. In a vacuum, on the other hand, both the "effective" oxides and pure platinum only emit negative ions, whose number increases strongly as the temperature rises. But the number of ions emitted by the oxides is about 1,000 times greater than the number emitted by the platinum. Richardson has represented the relation between the temperature and the number of negative ions given out by the pure platinum in a vacuum by an exponential formula derived from the Maxwell-Boltzmann law of the distribution of velocities. In this formula is contained the number of negative electrons per unit volume of platinum. The author finds that the same formula also applies to metallic oxides, but the calculation of the number of negative electrons contained in unit volume of the oxide gives a number which is about 100 times that of the molecules contained in the same volume. From this the author derives the interesting result that every molecule must be accompanied by numerous negative electrons.

SCIENCE NOTES.

Decrease in Weight of Incubating Eggs.—Mr. H. S. Gladstone, in the Ibis, contributes an extremely interesting note wherein he shows, by a series of careful weighings, that eggs lose in weight during incubation. Experimenting with pheasants' eggs he shows, in a table of averages, that between the first day and the twenty-third the loss is as much as 2 drachms 12 grains. Weighed every fourth day the loss on the average varies between 9 and 10 grains. The history of any single egg is sometimes very striking; thus an egg which, just laid, weighed 17 drachms 19 grains at the twenty-third day only turned the scale at 13 drachms 10 grains.

Messrs. A. J. Patten and E. R. Hart state that practically all the soluble phosphorus-containing constituent of wheat-bran is a magnesium-calcium-potassium salt of an organic phosphorus acid. The acid has the formula $C_2H_8P_2O_9$, and is probably identical with Posternak's anhydro-oxymethylene diphosphoric acid. The alkali salts of this acid are freely soluble in water, the calcium and copper salts are slightly soluble, and the barium and strontium salts are but sparingly so. The acid and its salts seem to be widely distributed in the vegetable kingdom, having been met with in the seeds of the red fir, peas, beans, and lupines, and in the potato and other tubers and bulbs.

A. Trillat finds that formaldehyde is invariably present in the products of combustion and smoke whenever organic matter is burnt, varying in the proportion from 1 : 1,000 to 1 : 10,000, of such substances as wood, paper, pure cellulose, rubber, and tobacco. Even simple hydrocarbons, such as benzol, give an appreciable quantity, 1 : 120,000 of its weight, when it is burnt; toluene gave 1 : 80,000, and xylene 1 : 40,000. Although the amount formed may vary with the conditions under which the organic matter is consumed, formaldehyde is a constant and normal constituent of the combustion products. Probably the air of smoky manufacturing towns will prove to be richer in formaldehyde than that of ordinary localities.

A gorgeously colored Oriental bat (*Cerivoula picta*), whose wings are brilliant orange and black, has been generally supposed to owe this coloration to a protective resemblance to the decaying leaves and ripe fruit of the plantain, among which it commonly dwells. A correspondent of Capt. Stanley Flower has, however, stated in one district of Siam this bat reposes in the flower of the Cala lily. The color of this lily is not stated, but it may be presumed that it is somewhat similar to that of the bat. In commenting on the statement, Dr. Jentink, of Leyden, remarks that "it sounds like a wonderful tale, a golden red and black colored bat sleeping in a lily-flower!" Can it be that the plantain bat has a double color-adaptation—to the plantain in India and to the Cala lily in Siam?

The August issue of the Proceedings of the Zoological Society of London contains two colored plates of Asiatic wild asses now living in the Duke of Bedford's park at Woburn. The two species portrayed are the kiang, or wild ass of Tibet, and the chigetai, or wild ass of Mongolia. The description of the two animals is by Mr. Lydekker, who, we understand, has written a paper on wild asses generally, which will shortly be published in Novitates Zoologicæ, the official journal of Mr. Rothschild's private museum at Tring. To the journal first mentioned Mr. Lydekker also contributes some notes on the extinct quagga, in which he confirms the alleged existence in the skull of that species of a vestige of the cavity for the face-gland which was fully developed in the ancestral three-toed hipparion. He also refers to the recent gift to the British Museum of a portion of the head-skin of a quagga shot in the forties, which had been made into a sheath for a hunting knife.

An interesting paper was communicated to the meeting of the British Association of Science at Cambridge by Prof. L. Errera, of Brussels, which dealt with the micro-chemical methods by which alkaloids may be located in plants. According to the results it would appear that the qualitative and, to some extent, the quantitative distribution of alkaloids (and especially those belonging to the pyridic series) can be determined micro-chemically in the various organs of the plant with certainty. In living cells the alkaloids are eliminated from the protoplasm and gather in the vacuole, and it is only in cells which have lost all their liquid contents (as in ripe seeds) or in dead cells that they accumulate in the protoplasm or the cell wall. The alkaloids are generally found to be localized. In very active tissues they occur chiefly in the neighborhood of growing points and in the ovules. In the epidermis the alkaloids are commonly found in the epidermic hairs, and often also in the sub-epidermic layers of vegetative organs as well as in the outer layers of fruits and seeds. In certain of their phloëm elements and in the neighborhood of the pericycle, alkaloids occur encircling the fibro-vascular bundles. They are found also in the phallogen and the youngest cork cells and in laticiferous or similar elements when present. The micro-chemical method has brought to light many more alkaloid-bearing plants, and it is suggested that the application of the method to animal tissue would reveal the existence of organic bases. According to Prof. Errera, the results of study seem to show that alkaloids are waste products resulting from the katabolism of cytoplasm and secondarily employed for defense against attack by animals. A few grains of alkaloid constitute a protection not less efficient, he remarks, than the strongest spines.

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