the inhabitants of Minnesota ought not to be in ignorance hereafter as to the mushroom species of that state.

The book opens with an introductory page of generalities regarding fungi, among which we are glad to find that the Roman pronunciation of the Latin names of families, genera and species is given as the proper one to be used. Then follows keys and descriptions, accompanied by 124 reproductions of photographs. The attempt has been made by the author to write his descriptions in such non-technical language as will render them intelligible to the reader who is not an expert in mycology. Even the non-botanical reader will be able to master the necessary terms by referring to the glossary at the end of the volume. Four color plates add to the interest of the book. The last chapter deals with collecting and cooking mushrooms. Enough advice is given here to prevent any danger from the use of poisonous species, and there are enough recipes to start out the neophyte mycophagist happily and safely.

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THE SCIENTIFIC RESULTS OF THE FIRST CRUISE OF THE "CARNEGIE" IN MAGNETISM, ELECTRICITY, ATMOSPHERIC REFRACTION AND GRAVITY[1]

THE first cruise of the *Carnegie* began at Brooklyn in August, 1909, and ended at the same place in February of the present year. During this period of about six months, a total distance of 8,000 nautical miles was covered in the north Atlantic Ocean between the parallels 51° north and 19° north and the following ports were visited: Greenport (Long Island), St. John's (Newfoundland), Falmouth (England), Funchal (Madeira), Hamilton (Bermuda) and Brooklyn (New York). Last June the vessel started out once more, this time on a circumnavigation cruise of 65,000 miles to extend over a period of three years and to embrace the Atlantic, Indian and Pacific Oceans. The vessel has already completed a voyage of nearly 7,000 miles since she left last June and is now at the mouth of the Amazon River. The present voyage has not only cut across our first cruise, but is so arranged, by the introduction of loops, as to intersect itself also at various points. We are thus enabled to apply numerous checks.

In addition, special observations have been made in Gardiner's Bay, off Long Island, and on the neighboring islands at the beginning of the first cruise in September, 1909, and again at the beginning of the present cruise in June of this year. The results of all these elaborate tests have shown conclusively that, with a non-magnetic vessel like the *Carnegie* and with the instrumental appliances and methods used, it is possible to secure an accuracy in the magnetic results approaching that of land observations.

As I am to cover four lines of activity on this vessel in the space of a quarter of an hour, it will not be possible to go into further detail and I shall have to content myself with stating at once the main conclusions reached.

A. *Terrestrial Magnetism.*—Except for the portion of the cruise from 48°.5 N., 47° W. to Falmouth Bay and thence to Madeira, all charts show too low west magnetic declination over the portion of the Atlantic Ocean covered by the *Carnegie*. While the correction is in general less than a degree, it is unfortunately in the same direction for about 5,000 miles, and hence the resulting error in a ship's course based on the present mariner's charts may be accumulative and ultimately reach a considerable amount. The maximum chart error at any one point may be from 1°.3 to 2°.6 according to the chart used.

The chart corrections both for magnetic inclination and horizontal intensity, often being of opposite signs on the portion of the *Carnegie's* first cruise, the average algebraic correction is in consequence at times greatly reduced. The average chart correction (sign not being considered) for magnetic dip approximates 1°.5 to 2°; the maximum correction for the British chart is 2°.5 and that of the German 4°.4. It is also seen from the values of the average algebraic dip correction,

[1] Read at the meeting of the American Physical Society, New York, October 15, 1910.

that the British chart gives, in general, too small dips and the German too large ones. The average chart corrections for magnetic horizontal intensity, disregarding sign, approximate 8 units of the third decimal C.G.S.; the maximum correction is about 15 units for either chart. For the greater part, both charts give, in general, too high values.

The observations received from the present cruise down to Porto Rico, which are already in my office, and the cable dispatch received from Mr. Peters, in command of the *Carnegie,* when he arrived at the mouth of the Amazon on September 24, prove that the results of the first cruise are being borne out by the present one. The *Carnegie* left Para on the fifteenth instant to continue her journey down the South American coast as far as Buenos Aires, from thence she will cross to Cape Town, arriving there towards the end of March, 1911, where the speaker expects to join her. The present cruise will cover the Atlantic, Indian and Pacific Oceans, will have an aggregate length of about 65,000 miles and will terminate at Brooklyn about July 1, 1913.

B. *Atmospheric Electricity.*—Observations for specific conductivity of the atmosphere, with a Gerdien conductivity apparatus, and the detection of the presence of radio-active emanations, using an apparatus of the Elster and Geitel type, were taken on the *Carnegie* by Mr. Edward Kidson on the portions of the cruise between Falmouth and Madeira and Bermuda, and Bermuda and New York. The plan was to devote alternate days to conductivity and radio-activity observations. This program was interfered with by bad weather and by the failure on some occasions of the Zamboni dry pile which was used to charge the collecting wire in the radio-activity experiments.

From the observations obtained, no connection could be established between atmospheric pressure, humidity, wind or cloud and the conductivity. When, however, there was a visible fog or haze the conductivity was greatly reduced. Rain squalls of short duration did not produce any effect. As the conductivity is an extremely variable quantity, a very large number of observations is required before the connection with meteorological conditions can be thoroughly investigated. One effect that was noticed was that a low conductivity was invariably obtained when the vessel was in the neighborhood of land. This effect was heightened in Long Island Sound on the vessel's return in winter by the state of the atmosphere then prevailing and probably by the presence of snow on the land and ice on some stretches of water.

Another noticeable fact was the persistent excess of the positive conductivity over the negative. The only occasions on which the reverse appeared to be consistently the case were while the ship was at anchor off Madeira and in Hamilton Harbor, Bermuda. This higher value of the positive conductivity is probably due chiefly to the accumulation of positive ions near the negatively charged earth's surface. If this were so, then the effect should not be so noticeable in balloon observations, as believed to be the case.

None of the present theories seem sufficient to explain the high degree of ionization observed in the air.

On December 18–19 continuous observations of the conductivity were taken over practically twenty-four hours, in order to discover, if possible, a diurnal variation. The day was exceedingly calm and fine, with a glassy sea with a smooth, low swell. The results point to a higher value of the conductivity at night than during the day, and to an almost constant value at night. This latter effect is more obvious if the individual observations be all plotted, when the variations are seen to be much greater and more irregular during the day time. It would be interesting to secure more of these continuous observations.

The chief results of the observations for the detection of radio-active matter in the atmosphere are as follows: The evidence thus far gathered points to the absence of any considerable quantity of thorium emanation in the air over the ocean, however, more observations are needed to decide the question definitely. On several days, when the vessel was very far from land, very little activity was collected; particularly was this the case on December 11, 14 and 18. The region in which this happened was a very calm one, and the air had probably not been in contact with the land for many days. Mr. Kidson is inclined to think, therefore, that the land is the chief source of the radio-active matter in sea air. This is what would be expected from determinations of the radium content of sea water. The fact that Mr. P. H. Dike, the observer on the *Galilee* in the Pacific, could obtain no evidence of radio-activity except near land, also points to this conclusion. The Pacific Ocean being of so much greater extent than the Atlantic, there should be much larger tracts over which the air had lost any radio-activity got from the land. The absence of thorium emanation would tend to confirm this theory.

It is easy to understand that the air in the North Atlantic between Newfoundland and England may at times have all been over land surfaces within a week. This may account for the results obtained by Professor Eve in this region.[2] Observations comparing the amounts of radio-activity over land and ocean are much needed.

C. *Atmospheric Refraction Observations.*—These observations consisted in the determination of the "dip of the horizon," being made for the purpose of controlling the corrections to be applied to the astronomical observations on account of atmospheric refraction. The observer was J. P. Ault, the navigating officer on the first cruise, Pulfrich's dip measurer, made by Zeiss, being used, in which, by the aid of prisms, the two horizons to the right and to the left are seen as two parallel vertical lines in the field of view of the small telescope, the distance apart of the lines being equal to twice the angular value of the dip of the horizon, read off in minutes by means of a scale.

The corrections found on the values obtained from atmospheric refraction tables were, in general, negative, reaching a maximum of $-1'.02$, showing the tabular value to be too large, however, on the portion of the cruise between Bermuda and New York the corrections in the mean are positive, the maximum being $+1'.23$. The dip of the horizon being a correction which is applied directly to an observed altitude of a celestial body, if then in case the latitude is obtained from meridian altitudes it would be in error by the same amount as the dip correction, hence in the maximum $1\frac{1}{4}$ of a minute of arc or of a nautical mile, or nearly $1\frac{1}{2}$ statute miles. The error in longitude will vary from one minute to over three minutes of arc, allowing a celestial body an azimuth of over thirty-five degrees from the meridian and for a range in latitude from twenty degrees north to fifty degrees north; for extreme conditions the error may even be greater.

It is thus seen that it is highly desirable for the mariner to have accurate tables of atmospheric refraction, especially near land, where an error of a mile or two in the ship's position is a matter of grave importance. In fact our attention to the need of such observations was first called by mariners themselves, who have found at various times when nearing the coast, where the opportunity was afforded to check their astronomical positions by land objects, that their positions were out presumably due to the tabular values of atmospheric refraction. How far the refraction corrections may depend upon prevailing meteorological conditions must be left for future examinations when additional data are at hand.

D. *Gravity Observations.*—Suggestions have been received from various sources that it would be highly desirable to include, if possible, gravity work on the *Carnegie*. In 1905 I consulted Professor Helmert, director of the Geodetic Institute at Potsdam, as to the possibility of attempting such work on the *Galilee*, which at the time was chartered, as may be recalled, for the magnetic work in the Pacific Ocean. One of his assistants, Dr. Hecker, had employed the method of getting gravity results at sea by determining the temperature of the boiling point of water, deducing therefrom the corresponding atmospheric pressure and comparing this with the observed mercur-

[2] A. S. Eve, "Terr. Mag.," v. 15, 1909 (25).

ial barometric height referred to normal gravity, the outstanding difference being the measure of the gravity anomalies within the inevitable observational errors. He had made a cruise on a passenger steamer in 1901 from Hamburg to Rio de Janeiro and back to Lisbon; again in 1904 he made further cruises in the Indian and Pacific oceans and in 1909 also in the Black Sea. As the result of Hecker's experiences, Professor Helmert did not think it possible to get anything of value on such a small vessel as the *Galilee,* and we accordingly made no attempt.

However, on the *Carnegie,* it was decided to make as frequently as possible determinations of the temperature of the boiling point of water with the prime view of obtaining the data required for controlling the corrections of our aneroids. The instrumental equipment was in accordance with this chief purpose, and hence only two boiling point apparatuses, furnished each with a thermometer, and an ordinary Green marine mercurial barometer, were provided. In all one hundred and two determinations were made, representing seventy-five different points, four of which were the ports Brooklyn, Falmouth, Madeira and Bermuda. It should be said that the observer, Dr. C. C. Craft, had no idea of the possible use of his results for gravity; however, a very searching examination has convinced me that with the necessary refinement in instrumental equipment and in method of observation it will be possible to obtain gravity results on the *Carnegie* worth while. While the results on the first cruise can not be used for determining the gravity anomaly over any restricted area, a general deduction can be drawn, in view of the large number of observations and the varying conditions under which they were made, which harmonizes with the general conclusion of Hecker's work, namely, that gravity is in general normal over the deep oceans, the defect in the density of the aqueous material above the ocean bottom being made up very nearly by increased density of the material below the ocean bottom. If we average our results then the mean anomaly over the deep part of the Atlantic Ocean, three to seven kilometers, differs from the mean over the shallow part along the coasts, five to two hundred meters, by about $+0.04$ of a dyne, meaning that there is a slight defect in gravitational force over the deep ocean by that amount as compared with the force over shallow water. This is to be regarded merely as a provisional result, the indication being that the final reduction may diminish the quantity to $+0.03$ or even to $+0.02$ dyne. Our result is in the same direction as Hecker's conclusions, he getting figures on the order of $+0.02$ to $+0.055$ of a dyne. A difference of .035 of a dyne would correspond approximately to an error of 0.001 of a degree in the temperature of the boiling point of water. The average difference in the temperatures of the boiling point for the two thermometers used and for a single determination was 0.003 of a degree; the average result above depends upon 75 stations. In his latest work Hecker employed nine specially constructed mercurial barometers and six thermometers and six boiling point apparatuses.

In connection with this investigation I have had occasion to examine into the various tables for obtaining the atmospheric pressure corresponding to the temperature of the boiling point of water, the latest of these tables in general use being those of Wiebe's given in Landolt-Börnstein's "Physikalisch-Chemische Tabellen." The most recent observations appear to be those of Holborn and Henning. For the purposes of gravity work, it is essential to be able to obtain accurately the atmospheric pressure for a comparatively limited range extending below and above 100° C.; the observations on which the tables are based on observations at larger intervals and the interpolation is accordingly somewhat uncertain. It is quite possible that the atmospheric pressure as taken from the tables may be out .05 to 0.1 mm. which corresponds to 0.065 to 0.135 of a degree in gravity. When dealing with only differential results of gravity, as we are in the present instance, the tabular errors are somewhat eliminated, though not wholly. I desire to bring this problem of more accurate vapor tension tables for water between 99° and 101° C. to the attention of physicists.

In conclusion, it should be emphasized that we propose to use the boiling point method only for getting *differential* results in gravity and not for absolute results. All necessary refinements are now to be introduced in the future work.

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SPECIAL ARTICLES

THE NATURE OF ELECTRIC DISCHARGE

At a meeting of the Academy of Science of St. Louis, on October 17, the writer presented photographic plates which strongly confirm conclusions reached in former papers.[1] Pin-head terminals rest with their rounded heads upon the film of a photographic plate. Their distance from each other is about 7 cm. One terminal is grounded in the yard outside of the building. The other leads to a variable spark-gap at the negative terminal of an 8-plate influence machine, the positive terminal being grounded on a water-pipe. With very short spark-gaps, the passing of a single spark produces discharge images immediately around the pin-heads. Increasing the spark-length enlarges the images, which are in the nature of brush discharges. The negative glow around the pin-head which communicates with the negative terminal of the machine increases very little in diameter, and the discharge lines in it are radial. The discharge lines around the grounded pin-head for short sparks follow approximately the lines of force. With longer sparks they are somewhat distorted, as if beaten back by a blast from the opposite or negative terminal. As has been suggested in the papers referred to these discharge lines in the "positive column" are drainage lines, along which Franklin's fluid is being conducted into the positive or grounded terminal. The portions of the air molecules which constitute the stepping stones for the negative corpuscles are urged in a direction opposite to that in which the negative discharge is flowing, thus promoting the lengthening of the drainage lines. Many hundreds of plates have been exposed in an attempt to adjust the spark-gap so that these drainage lines would end just outside of the negative glow without reaching it. In this way the length of these lines may be gradually increased until they approach the dark space around the negative glow. This dark space is a region where convection of atoms which have been supercharged within the negative glow are urged by convection away from the negative terminal. If the drainage lines reach this convection region, they cross it and reach the negative glow. It has thus far been found impossible to have them end within this Faraday dark space. If the spark-gap at the machine is so adjusted that only one or two drainage lines reach the negative glow, these lines will unite end on with the radial discharge lines of the negative glow. At the same time there is a distortion in the lines at and near their union, which reveals the commotion produced by the opposing "electric winds."

If now the spark-gap at the machine be slightly increased, other drainage lines reach the negative glow. They cross its radial discharge lines, and even extend beyond the negative terminal. In a few cases the entire area of the negative glow is traversed by these drainage lines. It is evident that we have here the same conditions that Goldstein found in the vacuum tube. These drainage lines are the canal rays of the vacuum tube.

This explanation of the nature of electric discharge enables us to understand why the positive column in a vacuum tube follows the tube in all of its windings and bends. It is not a convection column, but a drainage column. It is a conduction column. The conditions are different from those in a copper wire, in that the parts of the atoms which constitute the conductor are in gaseous form, and are capable of yielding to the force which urges them in a direction opposite to that in which the negative corpuscles are being urged.

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[1] *Trans. Acad. of Sc. of St. Louis*, XIX., Nos. 1 and 4.