

One of the most interesting series of such comparisons was that made recently at the standardizing observatory of the Department of Terrestrial Magnetism between our previously adopted standard magnetometer and a sine galvanometer, designed by Dr. Barnett and constructed in the workshop of the Department. With the latter instrument the value of the horizontal intensity of the earth's magnetic field is determined by an electric method, whereas with the standard magnetometer the same magnetic element is obtained by the usual magnetic method. The results of the comparisons between the two instruments showed satisfactory agreement in the values of the horizontal intensity obtained by the two independent methods.

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#### FURTHER RESULTS OF LINE INTEGRALS OF THE EARTH'S MAGNETIC FORCE.

BY LOUIS A. BAUER AND W. J. PETERS.

A PAPER was presented by the first author at the joint Chicago meeting of Section B of the American Association for the Advancement of Science and the American Physical Society, on December 30, 1920, giving results respecting possible vertical electric currents cutting the earth's surface. The results were obtained on the basis of the magnetic data accumulated by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington.

The present paper gives additional results as derived from recent computations of line integrals around circuits formed by the tracks of the magnetic-survey vessel, the "Carnegie," and the trips of land expeditions sent out by the Department of Terrestrial Magnetism.

One of the most interesting circuits was that formed by Cruise III of the "Carnegie" in the North Atlantic Ocean, in 1914 extending from New York to 80° north, off the northwest coast of Spitzbergen. This circuit embraces an area of 4,441,176 square kilometers. The result of the line integral around this circuit was such as would be produced by currents of positive electricity passing through the air perpendicularly through the earth's surface of average strength one twentieth of an ampere per square kilometer. For the sake of comparison it may be recalled that the line integral around the United States, as based upon the most recent magnetic data, gives a result which could be produced by currents of positive electricity passing from the air perpendicularly through the earth's surface, having an average strength of about one-thirtieth of an ampere per square kilometer.

From the foregoing it is seen that the results of two line integrals, one over an ocean area exclusively, and the other over a land area exclusively, are of the same sign and are practically of the same magnitude. On the other hand, the vertical currents as disclosed by atmospheric-electric observations, according to present methods over the regions of the two line integrals agree, however, in direction with the results of the magnetic line integrals. Quantitatively, there is a pronounced discordance. The strength of the vertical conduction currents

of atmospheric electricity is only about 1/10,000th of the currents indicated by the magnetic line integrals.

Another circuit for which the line integral has just been computed, is that formed by the track of the "Carnegie's" first cruise made in 1909-10. This circuit encloses an ocean area of 13,050,122 square kilometers and extends from New York to England along the track of ocean travel in latitude about 50 degrees north, thence to Madeira and finally back to New York by way of the sailing routes in latitude 20° north. The result of the line integral around this circuit is the same as that which would be produced by currents of positive electricity passing from the air perpendicularly through the earth's surface and having an average current density of one-twenty-sixth of an ampere per square kilometer. This is practically the same result as was obtained by the evaluation of the line integral around the United States.

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#### CHARACTERISTIC X-RAYS FROM LIGHT ELEMENTS.

BY A. LL. HUGHES.

THE characteristic x-radiations from the very light elements cannot be studied by the method of crystal analysis, as no crystal is known with spacings between its planes large enough to measure wave-lengths longer than about  $\lambda_{13}$ . To detect the characteristic radiations from the elements under examination, the photoelectric effect of the radiation from the element, when bombarded by electrons, was plotted as a function of the energy of the electrons. A break in the curve was taken to indicate the appearance of characteristic radiation and the corresponding wave-length was inferred from the quantum relation. The element (carbon or boron) was at a distance of less than a millimeter from an incandescent cathode which served as a source of electrons. In the same vacuum was a nickel or silver plate upon which the radiation fell giving rise to the photoelectric effect. Four gauzes at suitable potentials served to prevent the transfer of electrons or ions to the plate giving the photoelectric effect. Breaks were found at 215 volts ( $\lambda_{57.5}$ ) and 34.5 volts ( $\lambda_{358}$ ) for carbon, and at 148 volts ( $\lambda_{83.5}$ ) and 24.5 volts ( $\lambda_{505}$ ) for boron. These are the K and L radiations respectively for the elements investigated.

These values can be compared with the theoretical values obtained on extrapolating, by means of Moseley's relation, the known values for the x-ray wave lengths as given in Duane's "Data relating to x-ray Spectra." On extrapolating the values for the  $K\alpha_1$  emission lines (and converting into volts), we obtain 275 volts for carbon and 182 volts for boron, and on extrapolating the values for the Ka critical absorption frequencies we obtain 243 volts for carbon and 149 volts for boron. The method employed in this investigation should give values corresponding to the Ka critical points rather than to the  $K\alpha_1$  emission lines. The experimental value for boron (148 volts) is in good agreement with the extrapolated Ka value, while that for carbon (215 volts) is lower than the extrapolated value.