forms. Be this as it may, the present speaker is convinced that since really scientific legal investigation necessarily involves a study of the functioning of legal rules and principles in society, the traditional professional curriculum as it now exists in the law schools is not adequate for the training of the needed investigators. Indeed, one is justified in saying that the training in the traditional technique and nothing else, as now given in nearly all law schools, even though it follows a so-called liberal college education, is likely to destroy whatever fitness the student had for investigation of the kind demanded, for the reason that it tends to fix ways and modes of thinking which come down to us not merely from the middle ages but from the time of Aristotle; ways and modes which are as yet substantially untouched by the modern scientific outlook upon the world of thought.

There is thus a need that there shall be developed one or more university schools of what, for lack of a better term, we may call "jurisprudence," that is, legal science, with a curriculum avowedly adapted to the training of legal scientists as distinguished from practitioners of law. Above all, the students in such schools of jurisprudence should be given an insight into what a scientific approach to problems in any field is and what it involves, and so an appreciation of the difficulties to be overcome in applying scientific technique to the social sciences and especially to that of the law.

Underlying all that I have said will be found a postulate which has been tacitly assumed and not discussed, *viz.*, that a really scientific study of law, or as I prefer to say, legal phenomena, is possible. Into the justification for making this postulate I can not now go, although if time permitted cogent reasons could be urged for doing so. As it is, we shall have to content ourselves with saying that, unless we make it, all talk about research in law from a scientific standpoint is futile and a waste of time. That at the present moment a real science of law does not exist is obvious; but all that this signifies is that as yet no serious attempt has been made to apply a truly scientific approach to the study of legal problems. We are still in the era when professional philosophers who know almost nothing about law write books about the philosophy of law, just as earlier they wrote about natural philosophy and mental philosophy. These latter topics have now been turned over to the scientists who study physics and chemistry on the one hand and psychology on the other. If indeed the science of psychology is still in its earlier stages, it is because a completely scientific approach has not been achieved. At the present moment, however, psychology seems at last to be fairly on its way to the discovery of a sound scientific method of working. In like manner the dawn of a real science of law will doubtless be heralded by the disappearance of treatises upon the philosophy of law by professional philosophers who know little or no law, and the writing of such books by those who are not scientific experts in the field of legal phenomena will be as rare as the production of works upon the philosophy of medicine or of psychology by those not trained in those fields. Before this time comes, however, we must train a generation of legal scientists, sufficiently grounded in the broadest aspects of their field of study so that they can do worthily the work which the philosophers with inadequate legal training are endeavoring to do to-day. Such men will understand not only the possibilities of the technique they are using but also its limitations. When, and only when, we have a sufficient number of men trained in the manner suggested we shall have a genuine "philosophy" of law, using that term in its broadest sense, for then and only then will it be founded upon an adequate study of all the relevant phenomena by men trained in a sound scientific technique.

WALTER WHEELER COOK
THE JOHNS HOPKINS UNIVERSITY

(*Concluded in next issue*)

COSMIC ASPECTS OF ATMOSPHERIC ELECTRICITY[1]

THERE being as yet no generally accepted theory to account for the origin and maintenance of the earth's negative charge, it is of paramount importance to continue observation and investigation of the laws and modus operandi of the changes to which atmospheric electricity is subject during the day, year, and from year to year. The present paper is confined to a statement of facts applying to the so-called electrically or meteorologically undisturbed days, *i.e.*, to "fine-weather days," or days of no negative potential and no pronounced disturbances. It is only for these days that it has been possible up to the present to deduce world-wide laws. These facts in their generality have received further confirmation since the chief theories regarding the earth's electric charge were proposed.

In one notable respect atmospheric electricity differs from the equally elusive subject, terrestrial magnetism, in that the fluctuations of the atmospheric-electric elements are of the same order of magnitude as the absolute elements themselves—not fractions of a per cent. as is usually the case with the fluctuations of the magnetic elements. Thus, even on an electrically undisturbed day, the potential gradient may

[1] Presented at the Philadelphia meeting of the American Physical Society, December 29, 1926.

change from minimum to maximum during the day, or during the year, by a quantity approaching and even equalling its mean daily or annual value, which normally is about 130 volts per meter.

Among the most striking facts is the one which my colleague, Dr. S. J. Mauchly, first found on the basis of the observations made on the various cruises of the *Carnegie*. A discussion of these observations enabled him to announce[2] at the Washington meeting of the American Physical Society in April, 1921, "that the chief component of the *diurnal variation of the potential gradient* over the major portion of the earth (especially the oceans) is a 'wave' of 24-hour period which occurs simultaneously in all localities." Susbsequent investigations[3] by Dr. Mauchly, which included also observations at land stations, led to a general confirmation of this conclusion.

Dr. Karl Hoffmann, evidently unaware of Dr. Mauchly's communication of 1921, announced[4] in 1923 that the daily extreme values of the potential gradient at Arctic and Antarctic stations, as shown by the available series, occur everywhere at about the same absolute time.

Recent observations in Arctic regions and elsewhere have confirmed in the main the validity of the conclusions by Mauchly and Hoffmann. We have now available for this purpose a series of potential-gradient observations made by the Department of Terrestrial Magnetism in cooperation with the McMillan Expeditions to Baffin Land, 1921–22, and the Northwest Coast of Greenland, 1923–1924, also at the two observatories of the department, one in Western Australia and the other in Peru. Furthermore, a valuable series of observations was obtained in cooperation with the department by Captain Amundsen's *Maud* expedition, 1923–1925. Dr. H. U. Sverdrup, in charge of the scientific work of the expedition, from a discussion of all available observations on meteorologically undisturbed days reached the following conclusion: "Our observations in the Arctic Sea, far from land or close to the coast near the 160th meridian of east longitude, give very positive confirmation of the conclusions by Mauchly and Hoffmann."

While Dr. Mauchly was investigating the *Carnegie* observations, referred to above, the writer suggested[5] to him that the observed diurnal variation of the atmospheric potential-gradient on a universal-time basis may find an explanation in its association with the asymmetry of the earth's magnetic field with reference to the earth's axis of rotation. It may be significant that, on the average, when the potential gradient reaches its principal maximum value the sun is near the meridian of the north magnetic pole and that when the gradient reaches its principal minimum value the sun is near the meridian of the south magnetic pole.

There are land stations, which, evidently because of local influences of one kind or another, show extreme values of the potential gradient at times differing an hour or more from the average times, and there are some land stations which exhibit double maxima and minima in the diurnal variation of the potential gradient. It is generally found at these latter stations that one of the maxima and one of the minima values occur near the average times of extremes of the potential gradient in undisturbed regions. Suffice it to say that all available data on hand at present show that if the hourly values of the atmospheric potential-gradient be plotted according to universal time there will be found a general agreement in phase among the curves for stations in very remote regions, such as is not exhibited if the hourly values be plotted according to local time.

It certainly must be regarded as an impressive and significant fact that the potential gradient of atmospheric electricity passes nearly everywhere through extreme values during twenty-four hours at about the same universal times, irrespective of whether the observing station be enveloped by sunshine or by darkness. When the potential gradient reaches its minimum, the value may only be about 20 per cent. of the mean daily value.

Turning next to the *annual variation of the potential gradient,* we encounter another fact of cosmic interest, namely, that generally from the Arctic to the Antarctic the maximum occurs during the six-month period, October to March, when the earth's distance from the sun is less than the mean distance for the year, and that generally the gradient reaches its minimum value during the six-month period, April to September, when the distance between the earth and sun is greater than the mean distance. Several investigators have previously drawn the conclusion from land observations, especially in the polar regions,

[2] *Physical Review,* new series, Vol. 18 (1921), pp. 162 and 477.

[3] See *Terrestrial Magnetism and Atmospheric Electricity,* Vol. 28 (1923), pp. 61–81, and particularly *Researches of Department of Terrestrial Magnetism,* Vol. V, Washington, 1926, pp. 387–402.

[4] *Beiträge zur Physik der Freien Atmosphäre,* XI Band, Heft 1, 1923.

[5] See S. J. Mauchly's report presented at the meeting of the American Geophysical Union, April 18, 1921, *Bulletin of the National Research Council,* No. 17, p. 77, Washington, D. C., 1922.

that the extreme values of the potential gradient occur at about the same time of the year, hence not at the same season everywhere. The writer in addition has found from a discussion of the *Carnegie* ocean observations, and recent land stations, that nearly everywhere the mean value of the potential gradient for the six months October to March, when the earth is nearest to the sun, is greater than the mean value for the six months April to September, when the earth is farthest from the sun.[6] Accordingly, distance of the earth from the sun, rather than season, appears to be the controlling factor.

If we confine our attention to series of observations since 1900, when more rigorous methods of observing were employed than formerly, two outstanding exceptions from the general rule just stated are found, namely, the observations at Helwan, Egypt, 1907–1914, and those made by Dr. G. Berndt at Buenos Aires, 1911–1912. Dr. Wait, of the Department of Terrestrial Magnetism, has carefully investigated the Helwan series and he has been led to infer that this station may be subject to disturbing influence, owing to the seasonal variation in sand storms. The results at Buenos Aires depend on electrometer readings made three times daily for one year from May, 1911, to April, 1912. It would be highly desirable that additional observations be obtained at these two stations and that the annual variation be derived on the basis of both electrically undisturbed and disturbed days.

On the average, from the Arctic to the Antarctic, the monthly mean values of the potential gradient vary during the year from minimum to maximum to the extent of about 60 per cent. of mean gradient for the year.

Another interesting fact is that the *daily range of the potential gradient* varies during the year, generally in the same manner as has been stated with regard to the gradient itself. In other words, the daily range is a quantity very similar to the potential gradient; the former may be looked upon as counted from the minimum value as the zero, whereas in the case of the usual potential gradient the earth is assumed at zero potential.

And now we come to the consideration of the question of a possible *relationship between changes in the annual values of the potential gradient and changes in solar activity during the 11-year cycle.* In a paper published in 1924,[7] I brought together all the available data through 1923. The chief conclusion was that "the probability is high that the atmospheric potential-gradient and its diurnal and annual ranges, as also the air-earth current, are subject to sunspot influence." For an average increase of 90 in the sunspot number, between minimum and maximum sunspottedness, the increases in the potential gradient and its diurnal and annual ranges were found to be about 30 per cent.

With the aid of fifty-nine series of diurnal-variation observations of the potential gradient made aboard the *Carnegie* in the different oceans during 1915–1921, including the year 1917, of maximum sunspot activity, I again investigated the matter in 1925,[8] reaching once more the conclusion already stated. Dr. Mauchly could not find any adequate cause for the observed changes in the potential gradient, other than the one already mentioned of possible effect arising from varying sunspottedness.

It will probably be necessary to await the completion of another cycle and the accumulation of data at widely distributed stations, not subject to local disturbing influence, before all the questions arising as to the precise nature of any solar-activity influence on atmospheric electricity may be definitely settled. However, renewed interest has been aroused in the problem and it is also gratifying in this connection that beginning in 1928 the observational work in atmospheric electricity aboard the *Carnegie* will be resumed.

Owing to the meagerness of available data, it is not possible at present to state whether, or not, the *electric conductivity* of the atmosphere is subject to cosmic influences.

It will be a long time before the question as to any possible *secular changes* in the atmospheric potential-gradient can be investigated successfully. For example, do the mean values of this gradient for a solar cycle vary from cycle to cycle, as does mean sunspottedness?

LOUIS A. BAUER
DEPARTMENT OF TERRESTRIAL MAGNETISM,
CARNEGIE INSTITUTION OF WASHINGTON,
WASHINGTON, D. C.

[6] *Researches of Department of Terrestrial Magnetism and Atmospheric Electricity,* Vol. V, Washington, 1926, pp. 382–384.

[7] *Terrestrial Magnetism and Atmospheric Electricity,* Vol. 29 (1924), pp. 23 to 32 and 161 to 186.

[8] See *Researches of Department of Terrestrial Magnetism and Atmospheric Electricity,* Vol. V, Washington, 1926, pp. 361–381.

AWARD OF FELLOWSHIPS BY THE GUGGENHEIM MEMORIAL FOUNDATION

THE award of fellowships totaling $143,000 to sixty-three scholars, writers, musicians and artists has been announced by the trustees of the John Simon Guggenheim Memorial Foundation. Seven of the awards were to enable completion of work undertaken