ing survey of the tobacco habits and opinions of prominent men and women, and cites testimonials typical of those received from several hundred distinguished persons, both smokers and non-smokers. The net results are (a) that such reports do not yield reliable information concerning the influence of tobacco; (b) that unexpected numbers and natures of people smoke; (c) that there is a general objection to the juvenile use of tobacco.

A second section of the book reports studies of the correlation between school work and the use of tobacco. Questionnaire returns and statistical studies, which are cited, show that, on the whole, school men agree that smoking and scholarship are incompatible, but the causal relations are obscure. Comparison of scholarship records with smoking proclivities yields a correlation of —.51. Among high school boys examined the smokers were found to be superior in intelligence tests. They thus fail to live up to their possibilities and the teachers put a good share of the blame on tobacco. Of course a correlation does not reveal causality, but it would at least appear from the data that something is operating to disinterest the more intelligent boys in scholarship and to attract them to tobacco.

Realizing the insufficiency of the foregoing data, the author devotes the last third of the book to a survey of the experimental studies of Dr. Clark L. Hull, detailed report of which is promised in a forthcoming monograph. With well-controlled technique, experiments were conducted on eighteen men college students to determine the effect of pipe smoking on twelve different work processes.

On seven of these tasks the average results are so small or so equivocal as to be negative or uncertain. Steadiness, accuracy in cancellation and facility in learning show impairment. Pulse is increased in rate and motor fatigue is lessened (the sign for muscular fatigue average on page 222 should be + instead of —). The net result is loss rather than gain in performance. The book concludes with a judicious summary of conclusions and a fifteen page bibliography of English books and articles. Throughout the book is distributed also a good deal of discussion concerning the possibility of influences not yet experimentally demonstrated.

In common with most studies of drug effects, individual differences are noted and it is time that such idiosyncrasies be more fully analyzed. Drug investigations already reported provide data which suggests very clearly an inverse relation between susceptibility to drugs and general mental competence. If these indications are reliable it is not "people of distinction" and college students, but instead the mediocre and the natively inferior who may best reveal the characteristic direction and nature of drug influences.

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SPECIAL ARTICLES

ON AN APPARENT EFFECT OF THE SUN'S ELECTRICAL CHARGE ON THE YEARLY VARIATION OF ATMOSPHERIC POTENTIAL GRADIENT

IT has long been known that the electrical potential gradient in the atmosphere undergoes an annual variation, being greater in winter than in summer. It seems still to be generally believed that this variation is due to a corresponding variation in electrical charges situated somewhere in the atmosphere, though all attempts to locate these charges have failed. On the other hand, Erman[1] showed in 1803 that all known phenomena of atmospheric electricity could be explained as due to induction by a negatively electrified earth. A similar theory was proposed by Peltier in 1836. In 1874 Sir William Thomson (Lord Kelvin) in his presidential address before the Society of Telegraph Engineers said:[2]

> I do not say too much, then, when I say that the statement that the air is positively electrified has been at all events a subject for ambiguous and contradictory propositions; in fact, what we know by direct observations is that the surface of the earth is negatively electrified, and positive electrification of the air is merely inferential.

And again,

> The result that we obtain every day of fair weather in ordinary observations on atmospheric electricity is precisely the same as if the earth were electrified negatively and the air had no electricity whatever.

1 Gilbert's Annalen, xv, 386.

2 *Soc. Telegraph Eng. Jour.*, Vol. III, p. 12.

The extensive work of Franz Exner has led him to the same conclusion, so that Erman's theory of atmospheric electricity seems at least worthy of careful consideration.

Attention has previously been called by the present writer to his conclusion that the negative charge of the earth is repelled by a similar charge on the sun. This would result in both a diurnal and a seasonal variation of the electrical potential of the earth at any given place. The diurnal variation has now been recorded almost continuously by photographic methods for two and one half years at Palo Alto. The records show that, in general, the day side of the earth is electropositive to the night side.

A similar annual variation would necessarily follow from the interpretation which I have put on these results. In this case, the winter hemisphere of the earth should be electronegative to the summer hemisphere. Assuming the correctness of Erman's interpretation of the atmospheric potential gradient, this gradient should accordingly be greater in winter than in summer, and it should vary in some manner with the altitude of the sun.

Since only that component of the sun's inductive repulsion which acts toward the north or south would displace the earth's charge in these directions, and since this component must vary as the sine of the angle of the sun's declination from the vertical at any given place, it would seem that the diurnal variation of the atmospheric potential gradient at that place should, if undisturbed by other causes, vary approximately as the sine of the angle of solar declination.

It is known that measurements of the potential gradient give everywhere very irregular results. If the potential gradient is due to the induction of the earth's charge it should have a maximum value if the air were a perfect insulator, and would be zero if the air were a conductor. The air is a very good, though, owing to its containing always some free ions, not a perfect insulator. Its conductivity is too small to admit of direct measurement, but it may be computed from the number and mobility of the free ions which are found in it. Since the amount of its ionization varies, the conductivity of the air is likewise variable, and the potential gradient, which should vary in the opposite direction to the conductivity if it is an inductive phenomenon, should also be variable.

In a recent series of balloon measurements of both atmospheric conductivity and potential gradient which were carried to an altitude of about nine kilometers, Wigand[3] found the product of the potential gradient into the conductivity of the air to be nearly a constant at a given elevation, but to fall off with the altitude at the rate of about two per cent. per kilometer.

It is customary to call this product of the potential gradient into the conductivity of the air the "earth-air current." This hypothetical current is very small, amounting to about 1/100,000 ampere over a square mile of the earth, but it is regularly computed at some observatories. Now it is quite possible to give a different interpretation to this quantity. Thus, if the potential gradient varied inversely as the conductivity, the product of these two quantities would be the true potential gradient for some uniform condition of conductivity taken as unity, and it is this true potential gradient which should vary with the sun's declination.

Observatorio Del Ebro, at Tortosa, Spain, publishes tables of the mean monthly values of the earth-air current, and Figure 1 gives a comparison of the mean of these monthly values for the six years, 1914-19, with the monthly values of the sine of the angle of solar declination at Tortosa. The continuous line represents the mean values of the earth-air current, and the dotted line the values of the sines of solar declination for the corresponding months.

On page 715 of Hann's *Lehrbuch der Meteorologie* is given what is said to be the mean yearly variation of the atmospheric potential gradient for the north temperate zone between the parallels of 45° and 50° N. In Figure 2 the mean monthly values given in Hann's table are compared with the monthly sines of the angles of solar declination for latitude 47½° N. Here, as in Figure 1, the continuous line represents the atmospheric potential gradient.

In the southern hemisphere the same law seems to hold, though much less data on potential gradients are available from the southern

[3] *Ann. d. Phys.*, lxvi, 81; *Phys. Zeitsch.*, xxii, 623.

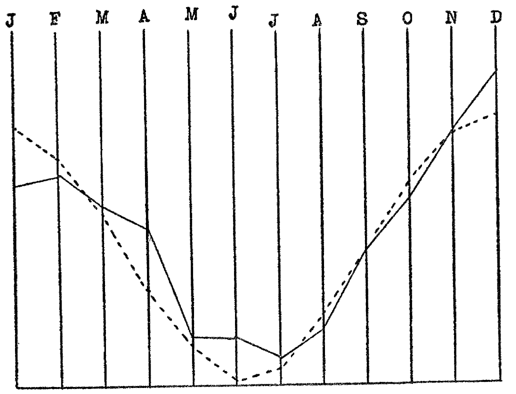

FIGURE 1. Relation of earth-air electric current to sine of angle of solar declination at Tortosa.

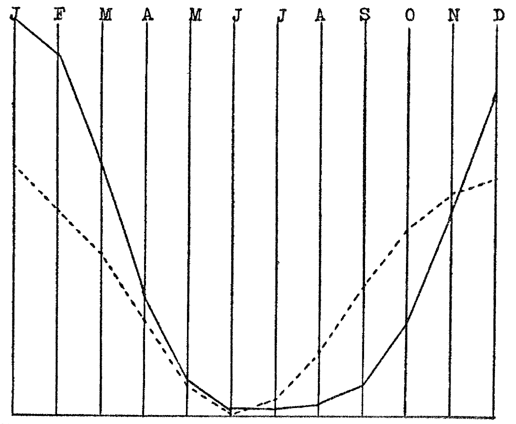

FIGURE 2. Relation of mean monthly atmospheric potential gradient to sine of solar declination for the region between 45° and 50° north latitude.

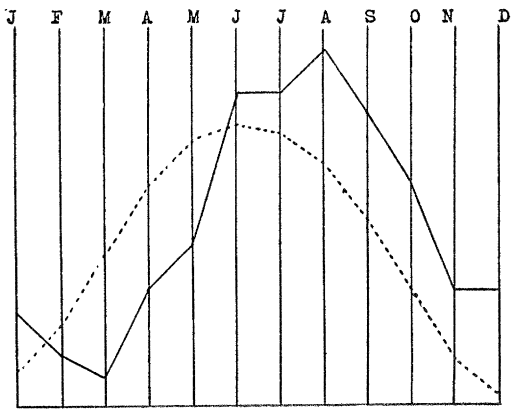

FIGURE 3. Relation of mean monthly potential gradient to sine of solar declination at Melbourne, latitude 37° 50′ south.

than from the northern hemisphere. The monthly potential gradient at Melbourne (Lat. 37° 50′ S.) is given in Hann's *Lehrbuch* and in Arrhenius' *Kosmische Physik,* p. 889. In Figure 3 this data is compared with the corresponding monthly values of the sine of the angle of solar declination for that latitude. The continuous line, as before, represents the atmospheric potential gradient.

In the case of Figure 3 the agreement between the two quantities is not as close as in figures 1 and 2, the data on potential gradient being more irregular than in the other cases. It seems probable that if the conductivity of the air at Melbourne were known, so that the earth-air current could be computed, it would, at least, give a smoother curve.

A more conclusive test of the theory should be given by a station near the Equator, where the curve for the sine of the solar declination must have two maxima and two minima during the year. A case of this kind may be found in the data from Batavia which are given by Hann and Arrhenius. The two curves for Batavia are given in Figure 4, their significance being the same as in the other curves given, the latitude of Batavia being taken as 6° S.

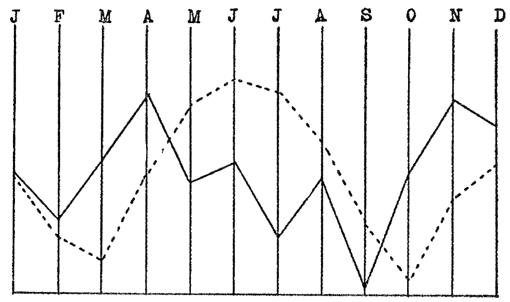

FIGURE 4. Relation of mean monthly atmospheric potential gradient to sine of angle of solar declination at Batavia, latitude 6° S.

The above comparisons seem to the writer to show that the yearly variation of the atmospheric potential gradient, especially when corrected for atmospheric conductivity, is such as would be expected to result from a negatively charged earth under the inductive influence of a similarly electrified sun.

FERNANDO SANFORD.

PALO ALTO, CALIFORNIA,
JANUARY 15, 1923