TABLE 2.—*Climatological data for Kansas.*

| Year. | Temperature (in °F.). | | | | | | | | Precipitation (in inches). | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Annual means. | | | | Annual extremes. | | | | Annual means. | | | Annual extremes. | | |
| | Eastern division. | Middle division. | Western division. | State. | Maximum. | Month. | Minimum. | Month. | Eastern division | Middle division. | Western division. | State. | Greatest monthly mean. | Month. |
| 1887 | 55.5 | 56.3 | 53.8 | 54.4 | 110 | July, August | —32 | January | 27.22 | 25.25 | 20.28 | 23.07 | 4.34 | August. |
| 1888 | 53.4 | 54.1 | 51.7 | 53.5 | 109 | ....do | —32 | ....do | 34.12 | 20.84 | 18.62 | 24.17 | 4.39 | Do. |
| 1889 | 53.4 | 54.4 | 52.9 | 53.6 | 108 | July | —17 | February | 37.01 | 32.52 | 19.51 | 29.47 | 5.48 | May. |
| 1890 | 54.9 | 54.9 | 54.8 | 54.8 | 113 | ....do | —22 | January | 31.79 | 23.58 | 14.88 | 20.65 | 4.06 | August. |
| 1891 | 53.9 | 53.1 | 51.9 | 53.0 | 108 | August | —10 | February | 34.00 | 32.79 | 29.21 | 30.90 | 6.28 | June. |
| 1892 | 53.3 | 53.5 | 51.6 | 52.6 | 111 | ....do | —34 | January | 39.63 | 27.78 | 17.98 | 29.06 | 6.90 | May. |
| 1893 | 53.8 | 54.7 | 52.6 | 53.7 | 113 | June, July | —15 | February | 30.23 | 18.58 | 11.98 | 20.12 | 3.91 | June. |
| 1894 | 55.2 | 55.5 | 52.9 | 54.7 | 116 | July | —26 | July | 28.76 | 21.25 | 12.19 | 20.72 | 4.94 | Do. |
| 1895 | 54.0 | 54.3 | 51.7 | 53.2 | 112 | ....do | —25 | February | 37.99 | 24.88 | 21.39 | 27.86 | 5.53 | July. |
| 1896 | 56.3 | 56.3 | 54.6 | 55.8 | 114 | June | —18 | January | 35.77 | 30.82 | 19.58 | 29.26 | 4.75 | May, July. |
| 1897 | 55.6 | 55.5 | 53.8 | 55.1 | 113 | ....do | —16 | January, December. | 27.56 | 22.91 | 22.91 | 24.58 | 3.69 | August. |
| 1898 | 54.4 | 54.3 | 53.0 | 54.2 | 110 | July | —23 | December | 42.72 | 29.39 | 22.13 | 32.35 | 6.28 | May. |
| 1899 | 54.3 | 54.6 | 53.4 | 54.3 | 110 | June | —34 | February | 33.20 | 27.98 | 18.11 | 28.01 | 5.53 | June. |
| 1900 | 56.0 | 56.6 | 55.3 | 56.0 | 110 | ....do | —15 | December | 37.61 | 27.39 | 18.51 | 29.65 | 6.37 | September. |
| 1901 | 55.6 | 55.6 | 54.1 | 55.4 | 112 | July | —21 | January | 26.00 | 20.89 | 17.91 | 22.15 | 8.64 | April. |
| 1902 | 54.3 | 54.3 | 53.9 | 54.2 | 112 | August | —22 | ....do | 45.71 | 34.30 | 22.24 | 35.50 | 6.64 | May. |
| 1903 | 53.9 | 53.6 | 52.2 | 53.4 | 110 | July | —22 | February | 41.88 | 32.41 | 19.78 | 33.46 | 8.57 | Do. |
| 1904 | 54.4 | 54.2 | 53.6 | 54.2 | 104 | August | —19 | January | 41.72 | 30.11 | 21.22 | 32.86 | 8.80 | June. |
| 1905 | 54.1 | 53.7 | 52.1 | 53.5 | 108 | June | —40 | February | 39.85 | 29.53 | 22.94 | 32.09 | 7.92 | September. |
| 1906 | 55.2 | 54.3 | 53.3 | 54.4 | 105 | August | —15 | March | 34.00 | 28.65 | 23.16 | 29.48 | 5.56 | June. |
| Twenty years | 54.6 | 54.7 | 53.2 | 54.2 | 116 | July | —40 | February | 35.34 | 27.09 | 19.70 | 27.77 | 8.80 | June. |

PRECIPITATION.

The average annual precipitation ranges from 15.37 inches in the extreme western to 44.54 inches in the extreme southeastern part of the State. The average number of rainy days per year increases from 49 in the extreme western counties to 99 in the eastern. The average precipitation for winter ranges from 1 inch in the western counties to 4 inches in the eastern. The average for spring ranges from 4 inches in the western counties to 12 inches in the eastern; for summer it ranges from 8 inches in the west to 14 inches in the east, and for autumn from 2 inches in the west to 8 inches in the east. The total annual precipitation during the driest year ranged from 9.30 inches at Viroqua, Morton County, to 29.62 inches at Columbus, in Cherokee County, and for the wettest year it ranged from 21.16 inches at Wallace, Wallace County, to 57.97 at Lebo, Coffey County, and 58.30 at Columbus, Cherokee County.

SNOWFALL.

The average annual snowfall ranges from 8.6 inches in Montgomery County to 25.6 inches in Atchison County, while in the western part of the State this order is reversed and we find it ranging from 18.1 inches in Thomas County to 21.2 inches in Morton. In the central part of the State McPherson County bears the palm with an annual average of 24 inches. The average annual number of days with measurable snowfall is least in the southern tier of counties, where it ranges from six to nine days, and greatest in the northeastern counties, where it is 15 and upward. The greatest snowfall in twenty-four hours is quite uniform over the State, ranging from 8 to 10 inches, but in the lower Solomon and Republican River valleys it increases to 11 and 12 inches. Around the headwaters of the Little Arkansas River, in McPherson County, it is 14 inches; in the valley of the Kaw it is 18 inches; in Morton, the extreme southwestern county, it is 20 inches.

THUNDERSTORM DAYS.

The average annual number of days with thunderstorms ranges from less than 20 in the extreme southwestern counties to over 40 in the eastern. Wichita, in Sedgwick County, has the greatest number, its record showing 49 days. Otherwise the number of days with thunderstorms is quite uniform, except in the extreme western and extreme eastern counties, ranging between 34 and 37.

HAILSTORM DAYS.

The average number of days with hailstorms is 2 in the extreme southeastern counties and 3 over the rest of the State, except in Trego, Ford, and Sedgwick counties, where the number is increased to 4.

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## LIGHTNING AND POWERFUL ELECTRIC DISCHARGES.

In a memoir on "High Electromotive Force" by Prof. John Trowbridge, of Harvard University, published in Vol. XIII of the Memoirs of the American Academy of Arts and Sciences, the author gives a full description of his remarkable battery of 20,000 small cells, giving an electromotive force of 40,000 volts.

Such a battery gives discharges one or two yards long that simulate lightning itself and lead to the following remarks by the author elucidating this phenomenon.

* * * Meteorological observations lead us to conclude that the lightning discharge is not produced like the discharge from a great number of storage cells arranged in series – that is, from one charged particle of water vapor to another—but rather from the accumulation in series of such charges at some point on the surface of the cloud, the cloud thus acting like a charged condenser. We can thus suppose that the outer layer of particles of water are more heavily charged than those in the interior of the cloud. * * *

It seemed evident from observation of the phenomena that air at atmospheric pressure breaks down with great facility under high voltage combined with large amperage.

* * * * * * *

One is impressed in studying high voltage combined with large amperage that the study of electrical discharges by means of Holtz machines or other forms of glass inductors leads to limited conceptions of the amount of energy in lightning discharges. If Benjamin Franklin had worked with a high-tension storage battery, he probably never would have dared to try his celebrated kite experiment. Experience has shown that even five hundred volts combined with large current is sufficient to cause death.

* * * * * * *

The discharges from a large number of condensers, charged in multiple and discharged in series, are probably more nearly identical with lightning discharges than any other forms of discharges within our experimental means; and the photographs of such discharges reveal details which do not appear in the discharges from Ruhmkorff coils or Tesla coils.

With a large portrait lens many of such details appear which are not shown by small lenses. These details, however, are difficult to reproduce. Indeed it often happens in scientific investigation that one obtains faint images which can not be reproduced by any process of printing, and which do not give satisfactory results with ordinary processes of intensification or methods of repeated printing from quick plates to slow plates.

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In the case of very long sparks, six feet, or more, the bifurcations are generally directed to neighboring conducting masses, and are not directed to the cathode. In the case of lightning, masses of clouds at a low potential, not lying along the main direction of discharge, are indicated by these side forking discharges.

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Some years ago I showed that an explosion occurs whenever powerful sparks change their direction in zig zags. The spark passed between a plate of glass and a sheet of paraffined paper, and it was found that the paper was perforated at each forking of the discharge. Possibly these explosions occurring along an extended lightning discharge may be an important element in the phenomenon of the rolling thunder, for the sound of such explosions would arrive at considerable intervals apart.

An interesting account of the explosive effect at each turning point of a lightning discharge has been given me by Mr. Harvey N. Davis, an instructor in the Jefferson Physical Laboratory, and I give it here, since it is an account by a skilled observer of both the above explosive effects and ball lightning.

"During the 27th of August, 1906, a large boarding-house on the side of Mount Moosilauke, in the town of Warren, N. H., was struck by lightning in an unusually sudden and severe thunderstorm. The path of at least three independent discharges could be traced, but they must have been practically simultaneous, for those who had been caught by the rain half a mile from the house heard only one sharp report. One of the discharges struck the end of the ridgepole of the barn, and came down the wall to a very obvious ground; and two others landed halfway up the sloping roof of the nearest part of the house, one of them near, but not on a dormer window, and the other at some distance from any sort of a projection such as would ordinarily be expected to 'draw lightning.' In each place there was a spot about a foot across where the shingles had been forced outwards, as though by an explosion just under them, while inside there were two round holes four or five inches in diameter where the plaster had been blown into the room, leaving the laths completely bare. The first of these discharges travelled down the roof to the eaves, and jumped to the telephone wires, bursting out the shingles again as it left the roof. It happened that one of the young women of the house had just closed the dormer window, and was in the middle of the room with her head close to that part of the sloping ceiling where the second of the holes was found. It is possible that this was merely chance, or, on the other hand, her presence may have had some inflence on the direction of the original discharge; at any rate, the discharge jumped to her right shoulder, and passed through or over the surface of her body to her left foot, then ran along the floor to the wall, leaving a mark such as might be made with a hot poker, and finally reached earth through the side of the house. The young woman was, of course, completely stunned, but was fortunate enough to escape serious injury. An interesting feature of this discharge was the regularity with which it seemed to explode every time it turned a corner. The explosions between the ceiling and the roof have already been mentioned; the next occurred when the discharge reached the woman's foot. Her shoe and stocking were blown completely off, so that only the left half of the upper of the shoe remained attached to the sole. From her foot it ran along the floor to a tin pail, which was standing on a piece of linoleum, and here it exploded again, overturning the pail, and demolishing the linoleum, some of which was found inside a water pitcher on a stand near by, while one or two shreds reached an adjacent windowpane with force enough to stick between the glass and the sash. Finally, the point where the lightning reached the wall and started down between the sheathing and plaster was very plainly marked on the outside of the house, a couple of clapboards being forced out several inches. In the room below, the plaster was loosened from the laths all the way down, probably by the pressure of the heated air, but the appearance was quite different from that of the ceiling in the room above. Fortunately nothing took fire.

"At the time of the discharge the guests were in the dining-room at the other side of the house, and several of those who turned most quickly saw slow moving ball discharges just outside the window. One of those with whom I talked, a trained scientist, was sitting with his back partly turned, and saw only one ball of fire, 'like a glowing coal;' but others said that it had been preceded by one rather larger, perhaps as large as a baseball. When he first saw the second ball, it was three or four feet from the ground, and was falling obliquely, as though it had rolled off the roof of a low ell near by, and its velocity was only a few feet per second, certainly not enough to leave a streak on his retina, as he noticed at the time. We searched that night, and again carefully the next day, for traces of these discharges in the ground, but could find none. Whether they were independent discharges from the main cloud, or were secondary effect, due to the electrification of the wet roof, I do not know. At any rate, they were not immediately connected with either of the three main discharges, for two of these went to obvious grounds, as has been indicated; and the telephone wires, which carried off the third, were nowhere near the part of the house where these balls were seen."



In long discharges of lightning these explosions, directed at varied angles, could give rise to sound waves, which, starting practically at the same instant, nevertheless, by different angles and degrees of reflection, could arrive at the ear of the listener at considerable intervals, and produce the rolling of thunder.

What, then, are the conclusions that can be drawn from the foregoing manifestations of electric discharges which can be produced by a large number of storage cells? The first fact which impresses one is the importance of the consideration of amperage as well as electromotive force. Throughout scientific literature, and in popular conception, electromotive force has received the chief consideration in discussing the phenomena of lightning. Experiments in laboratories have been conducted with electrical machines which are generally incapable of affording much current. Franklin's experiment with the aid of a kite illustrates an underestimate of the current in a lightning discharge. Even to-day no one would think of repeating Franklin's celebrated experiment, largely from a dread of voltage, but with little conception of the possibility of danger from small voltage and large current. We are beginning to realize, however, that 500 volts, accompanied by a current of from 10 to 20 amperes, is sufficient to destroy human life. One compartment of the storage battery which I have described in this memoir—a compartment affording something over 800 volts—short-circuited through the body of the janitor of the laboratory, was sufficient to knock him senseless.

The most powerful electric discharge which we can produce by modern appliances in a faint shadow of lightning—so faint that it fails to reproduce in most essential respects the phenomena in the heavens. I have never been able, by the use of resonant tubes or other arrangements, to cause reverberations to reproduce in the slightest degree, even with sparks six feet in length, the rolling of thunder. The energy of an ordinary lightning discharge must be enormous.

The forms of lightning discharges are very varied, and when one asks whether lightning is oscillatory, one should specify the kind of discharge.

## A COLLECTION OF MEAN ANNUAL TEMPERATURES FOR MEXICO AND CENTRAL AMERICA.

By Philip P. Calvert, Ph. D. Assistant Professor of Zoology, University of Pennsylvania, Philadelphia, Pa.

In studying the distribution of the Odonata, or dragonflies, of Mexico and Central America, particularly with reference to temperature, the writer prepared a colored map illustrating the distribution of mean annual temperatures in those countries. This map is shortly to appear as a plate in the Biologia Centrali-Americana volume Neuroptera (London). It is based partly on two similar older maps,[1] partly on a body of temperature data specially gathered from many scattered sources in the libraries of Philadelphia and of the United States Weather Bureau at Washington. As these data will probably be of use to climatologists and others, they are here brought together in tabular form. Since the authorities cited for temperature records often give other climatic data also, the column "Authority for temperature records" will also serve as a selected bibliography on meteorological phenomena in these countries. In the search for the earlier authorities much assistance was derived from Sr. Aguilar y Santillan's "Bibliografia Meteorologica Mexicana" in the Memorias de la Sociedad Cientifica Antonio Alzate, IV, p. 5–47, 265–276, 1890. The student of Mexican temperatures will also find Sr. J. Guzman's "Climatología de la República Mexicana desde el punto de vista higiénico" in the same Memorias, XX, p. 181-

[1] 1. A map, 97 by 71.5 centimeters, in the library of the Academy of Natural Sciences of Philadephia, inscribed merely "Carta Climatologica. Sebastian Reyes. P. J. Senties. A. Donamette Imp. Escala de 1:3,000,000. Gravée chez Monrocq fr. Paris." Thanks to the Secretaria de Estado y del Despacho de Fomento, Colonizacion e Industria of Mexico, I am informed, under date of July 30, 1907, "que dicha Carta fué publicada en 1889 por disposicion de esta Secretaría, haciendo los trabajos relativos los Sres. Pedro J. Senties, que era Director de la Escuela Nacional de Agricultura y Comisionado de México en la Exposicion de Paris del mismo año y Sebastian Reyes que fué Profesor del Plantel antes mencionado." This map was reproduced without alteration, but on a reduced scale (1:6,000,000), in Tomo XI, Anales del Ministerio de Fomento de la Republica Mexicana, Mex., 1898.

2. A map entitled "Reparticion de la Temperatura en la República Mexicana" for the "Año Meteorológico de 1902," published as Planche 16, Boletin Mensuel, Observatorio Meterológico-Magnetico Central de México, Noviembre, 1902. Señor Don Manuel E. Pastrana, Director of the Observatorio, has kindly informed me (September 6, 1907) that the maps for later years have not yet been published.