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CLIMATOLOGICAL DATA FOR JAMAICA.

Through the kindness of Mr. H. H. Cousins, chemist to the government of Jamaica and now in charge of the meteorological service of that island, we have received the following table in advance of the regular monthly weather report for Jamaica:

Comparative table of rainfall for August, 1903.
[Based upon the average stations only.]

Divisions.	Relative area.	Number of stations.	Rainfall.	
			1903.	Average.
	Per cent.		*Inches.*	*Inches.*
Northeastern division	25	23	16.54	8.15
Northern division	22	58	8.61	4.55
West-central division	26	25	15.05	9.60
Southern division	27	33	10.95	5.50
Means	100	139	12.79	6.95

The rainfall for August was therefore very much more than the average for the island. The greatest fall, 34.29 inches, occurred at Cedar Valley in the northeastern division while 2.40 inches were recorded at St. Anns Bay in the northern division.

THE HURRICANE OF AUGUST 11, 1903, AT JAMAICA.

By H. H. COUSINS, in charge Jamaica Weather Service.

A warning issued by the United States Weather Bureau was received at noon on August 8, stating that a cyclone off Barbados was traveling in a northwesterly direction. Later it was announced: "The disturbance east of Barbados will move northwest over the Windward Islands. Probably of dangerous strength."

Traveling in a direct line the cyclone first struck the extreme eastern end of the island at Morant Point a little before midnight on Monday the 10th. I am of opinion, from the data available, that the central track of the cyclone was through Manchioneal, Moore Town, Claremont, Browns Town, and Falmouth, and thence in a direct line to Grand Cayman and Yucatan where the hurricane finally spent its force.

The destructive zone of the cyclone was a little over 35 miles in width, and it attained its maximum width in Jamaica at a section from Galina Point north of Port Maria to central St. Catherine.

Points just outside this zone and in parallel line therewith are as follows: Port Royal, Hartlands, Rock River, Christiana, Cambridge, and Lances Point, west of Lucea.

This central zone involved destruction or injury to buildings and large trees. The whole of Jamaica, therefore, north of a line from Spanish Town to Lucea has been devastated.

From the records of the United States Weather Bureau office in Kingston the following observations may be drawn: The barometer fell .10 inch between 10 a. m. and 3 p. m. on the 9th; it recovered to 29.9 by 10 p. m. From this time it fell steadily .20 inch until 3 p. m. on the 10th, when a slight rise took place. Standing at 29.8 at 10 p. m., a rapid fall took place, and by 5:30 a. m. of the 11th the lowest point, 29.05, was attained. The rise was twice as rapid as the fall. By 11 a. m. the barometer had risen again to 29.8. The rainfall was only 2.25 inches.

At Moy Hall, in St. Thomas, 14.64 inches fell in 13 hours during the storm. The Kingston records represent those for a point estimated to be 16 miles south of the center of the hurricane. The cyclonic disturbance moved at a uniform rate of a little over 20 miles per hour, and its rotation counter-clockwise accounts for the change from the northwesterly winds during the first half to the southwesterly winds during the final stage of the hurricane.

SOIL TEMPERATURES AND VEGETATION.

By DANIEL TREMBLY MACDOUGAL.

A committee on the relation of plants to climate was appointed at the New York meeting of the American Association for the Advancement of Science in June, 1901, to which was delegated the task of carrying out some work upon the relations of plants to various climatic factors. The actual investigations planned by the committee were entrusted to the author for execution, and a set of thermographs was put in action in northern Idaho in the summer of the same year in addition to the battery that was installed in the New York Botanical Garden. During the following year some thermometric observations were made in the Mission Mountains and Kootenai Mountains, in northern Montana, and a paper was presented at the meeting of the Association in Denver, August, 1901, describing a method of estimating the total temperature exposure of a plant which would be specially applicable and useful in measuring the influence of temperature upon the shoots of plants.

The basal portions of a typical plant, often the larger part of the body, are imbedded in the soil at various depths, and no adequate study of the influence of temperature upon physiological processes could be made until some accurate, graphic, and convenient method was devised for taking continuous records of the soil. The committee was given a second grant by the Association, and additional funds were also voted at the Pittsburg meeting in July, 1902. By the aid of additional contributions from the New York Botanical Garden efforts were made to devise an instrument that would meet the above needs. The committee was so fortunate as to enlist the active interest and practical cooperation of Prof. William Hallock, of Columbia University, who undertook to design a thermograph that would make a continuous record of the soil at any desired depth. A single working model was constructed in the autumn of 1901 and was tested for several months in Professor Hallock's laboratory before being installed in the Botanical Garden, May 2, 1902. A description of this instrument, together with the records obtained for May, 1902, have already been published.[1] It will be profitable to repeat this description here, together with the accompanying illustration (see fig. 1).

The thermal element of the instrument consists of a copper bulb or globe 11 centimeters in diameter (fig. 1, A), with a strengthening equatorial ridge of solid metal, filled with commercial kerosene. A short section of copper tubing with the walls flattened on two sides for convenience of manipulation during construction is soldered to a suitable opening in one pole of the copper globe, and the free end of the heavy tube is likewise soldered to a small copper tube with an external diameter of about 4 millimeters and an internal diameter of 1 millimeter. This tube is also filled with petroleum and may be of any reasonable length up to 10 meters or perhaps more without vitiating the accuracy of the instrument to any appreciable extent. Furthermore, in practise this tube may be variously bent and curved in making adjustments without detriment to the results obtained (fig. 1, C).

The free end of the capillary tube is connected through an opening in the side with the chamber in the interior of a solid

[1] MacDougal. The temperature of the soil. Journal of the New York Botanical Garden. 3: 125-131. July, 1902.

brass block fastened to the base of the apparatus. Two pairs of convex, corrugated brass disks 8 centimeters in diameter are fastened together at the edges and the united pairs are then soldered together forming an expansion chamber composed of two disk-shaped cells, with an opening through the soldered portion (fig. 1, D). Next an opening is made in the center of one of the convex surfaces and this opening is joined by solder to the chamber in the brass block. The double expansion chamber is also filled with petroleum and care is taken to exclude all air from the tubes and chambers. The entire system is now seen to consist of a rigid bulb, tubes, and small base chamber terminating in an expansion structure which may dilate or contract with the alternations in volume of the fluid. It now remains to attach devices for properly demonstrating the movements of the upper wall of the expansion chamber in order to obtain the changes induced in alterations in temperature. To do this an upright post is fastened to the upper wall of the expansion chamber and this is provided with a sleeve and set screw which allows adjustments of its length in connection with a lever (fig. 1, E and F) 4 centimeters long running to an axis held in bearings between two upright standards. A second arm 17 centimeters in length, bearing a suitable pen is attached to this axis and extends so as to come in contact with a suitable upright recording cylinder revolved by clockwork. The long lever is built up of three parts and is provided with a device for adjustment and calibration (fig. 1 H). The cylinder carries double ruled paper and makes a single revolution in a week. In the construction of the working model described here, it was found convenient to use the levers and recording mechanism of a thermograph of German manufacture, the slips of which were ruled for degrees centigrade. The instrument was calibrated to meet these requirements, but new models now under construction are designed on the Fahrenheit scale. The improved model may also be constructed to carry thermal apparatus for taking air temperatures on one end of the base and the soil temperatures on the other end, thus making synchronous records.

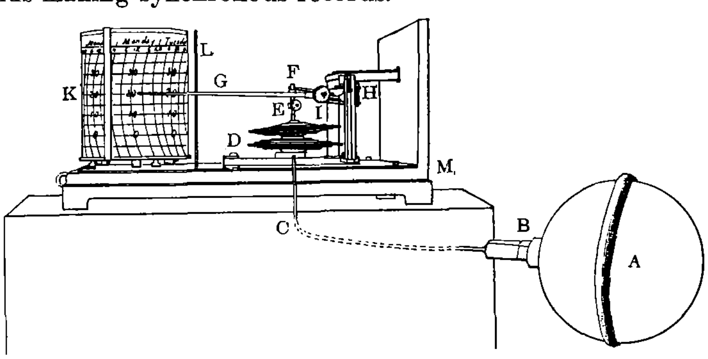

FIG. 1.—Hallock thermograph. A, bulb containing kerosene. B, heavy tube, soldered to polar opening in bulb. C, capillary tube connecting bulb with expanding chamber. D, double expanding chamber. E, upright post with adjustment clamp at E, on expansion chamber and fastened to short lever arm at F. G, lever extending from axis, and bearing pen, which traces temperature record on the cylinder. H, adjustment to raise or lower pen in making corrections and calibration. K, cylinder driven by internal clockwork which makes one revolution per week. The cylinder carries paper ruled horizontally to degrees centigrade. The rate of movement carries the paper past the pen at such rate that two hours is taken to pass over the interval between two curved lines. L, upright rod on hinged base to remove pen from contact with paper. M, base of cast iron.

The peculiar value of the above apparatus consisted in the fact that the recorder could be kept in an instrument shelter of any convenient pattern and the sensitive bulb carried out and buried in the soil at any desired distance from the shelter, or at any depth in the soil, by which the actual temperatures encountered by the roots of plants might be obtained. In practise it was found that the amount of liquid in the capillary tube and expansion chamber was so small in proportion to that in the bulb that the temperatures encountered by the tube or chamber made no observable error in the reading of the instrument. This was true to such an extent that the flame of an alcohol lamp applied to the tubes did not produce any change in the position of the pen upon the recording slip. The same is true of the effects of direct exposure to the sun's rays.

The location for the installation of the instrument for the trial series of records for the first year was a small area of clayey soil mixed with loam lying near the propagating houses and nurseries in the New York Botanical Garden. The drainage is free, as the surface of the ground is slightly sloping to the eastward. During the summer the place is covered by the shade of some cherry trees after 4 p. m.

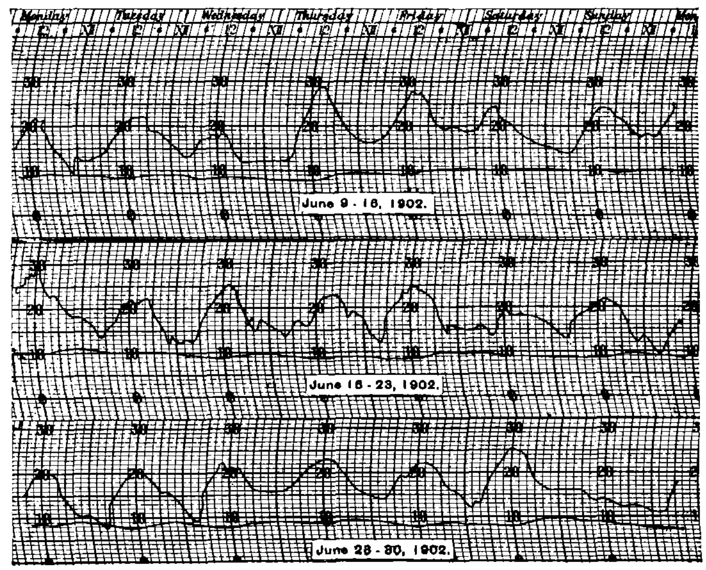

FIG. 2.—Tracings of thermographic curves of air, and of soil at a depth of 30 centimeters (1 foot), June 9–30, 1902. The daily periodicity and the direct effect upon the soil of changes in air temperatures are illustrated. Centigrade scale. The temperature of the air is shown by the uppermost of each pair of tracings.

In the installation of the instrument the recorder, together with an air thermograph, was placed in an instrument shelter of the United States Weather Bureau pattern. The capillary tube passed through the floor of the shelter to the surface of the ground, being protected from mechanical injury by being placed in a grooved board. A narrow trench 2 meters long and about 20 centimeters in depth was dug and was then prolonged in a tunnel to a farther distance of 50 centimeters. This tunnel was only large enough to receive the bulb, and after that had been pushed to the farther end of the tunnel the excavated soil was packed around it in a manner as nearly natural as possible. By this arrangement the layer of soil above the bulb was left undisturbed and artificial drainage conditions were not introduced. This arrangement brought the upper surface of the bulb in contact with the soil penetrated by the matted roots of grasses and other small herbaceous plants, which also extended much deeper around the excavation.

The greater bulk or volume of the root system of the smaller plants usually lies nearer the surface of the soil than the position of the bulb of the thermograph, but the important function of absorption is carried on chiefly by the younger, most recently formed terminal portions of the roots which lie deeper in the soil. The rate at which mineral and other substances in solution in the soil are taken up, the permeability of the protoplasmic membranes, the turgidity and consequently the rigidity of the roots are also greatly affected by temperatures, while the growth of these organs, together with their endurance and that of all underground organs, depends not only upon the actual temperatures encountered, but also upon the rapidity with which changes ensue.

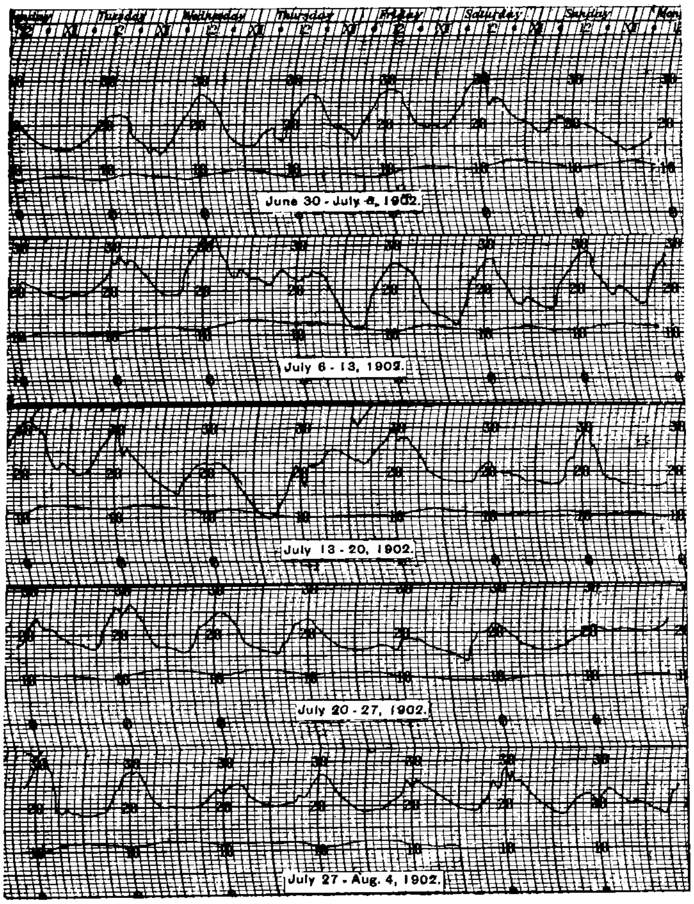

Fig. 3.—Tracings of thermographic curves of the air, and of the soil at a depth of 30 centimeters (1 foot), June 30–August 4, 1902. The maximum temperatures of the year are included. Centigrade scale. The temperature of the air is shown by the uppermost of each pair of tracings.

Before being placed in position the air thermograph and the soil thermograph were placed in a closed room with a standardized mercurial thermometer (No. 2792, G. S. Reichs-Anstalt, Berlin), and were found to read alike to within a small fraction of a degree, allowing for a slowness of response by the thermographs.

The records on hand now embrace a period of fourteen months, and the facts obtained seem to be of sufficient interest to warrant their discussion at the present time, together with some of the actual curves traced by the instruments.

It may be seen from these that the maximum daily temperatures occurred between 8 and 11 p. m., and the minima twelve hours later, or between 8 and 10 a. m. The optimum temperature for absorption by roots lies well above that of the soil at the depth at which the observations were made. It follows, therefore, that the temperature of the soil approaches this optimum most nearly, and offers most favorable conditions for the taking up of watery solutions at a time of the day when the amount of water thrown off by the shoot and of mineral matter used in metabolism are nearing the minimum by reason of the absence of light, lowered air temperature, and consequent increased humidity of the air. These inharmonious conditions account almost wholly for the profusion of guttation excretions or "dew drops" formed on the tips and margins of grass blades and leaves of low growing plants early in the evening. Absorption by the root continues quite vigorously after sunset by reason of the favorable temperatures, and the augmented amount of fluid in the cortex of the roots sets up a pressure which ultimately forces water into the central cylinder and up through the woody cells faster than it may be used and transpired by the thin-walled cells of the leaves. The vessels become filled with water which is forced out in liquid form through the excretory openings in the form of drops. In some species the amount of water coming away from the plant in this manner may reach quite an appreciable quantity.

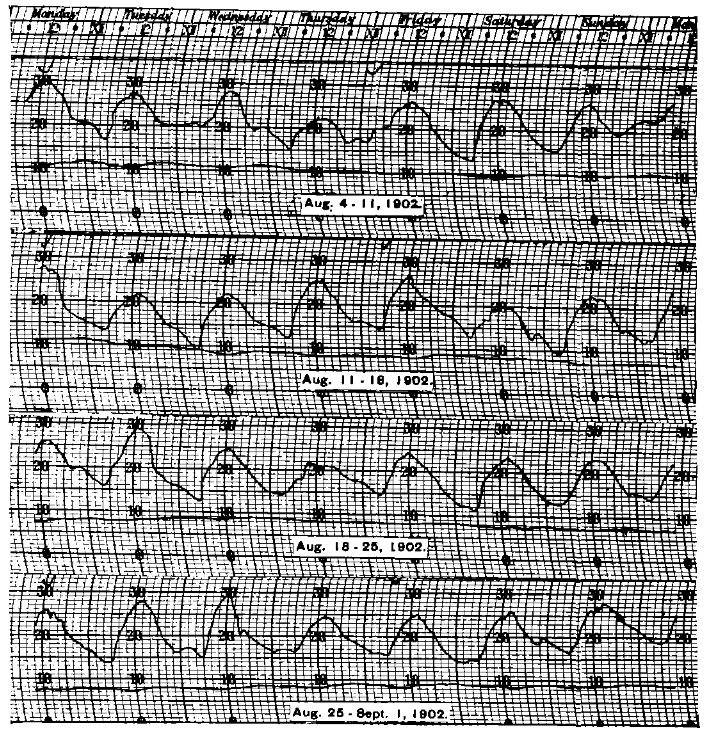

Fig. 4.—Tracings of thermographic curves of the air, and of the soil at a depth of 30 centimeters (1 foot), August 4–September 1, 1902. A period during which comparatively little fluctuation and variation occurs. Centigrade scale. The temperature of the air is shown by the uppermost of each pair of tracings.

On the other hand the forenoon witnesses the rapid acceleration of transpiration by all parts of the shoot at a time when the soil temperature is decreasing to a minimum. The increase of transpiration continues until mid-afternoon, while the temperature of the soil reaches a minimum two or three hours earlier and then begins to rise, but does not do so sufficiently to favor absorption to any great extent. It is true of course that the needs of the leaves may be partially met by the activity of the rootlets which lie nearer the surface.

The greatest amount of variation during twenty-four hours that was recorded during the year amounted to 2° C. (3.6° F.). This amplitude was shown on two occasions. June 28, 1902, the temperature rose from 8° C. (46.4° F.) at 10 a. m. to 10° C. (50° F.) at 10 p. m., in consequence of an increased temperature of the air, reaching a maximum of 27.8° C. (82° F.) at 1 p. m. The temperature of the soil fell from 12° C. (53.6° F.) at 11 p. m., on July 16, 1902, to 10° C. (50° F.) at noon on the following day. Curiously enough this minimum coincided exactly with that of the air a meter above the surface four hours earlier. A reverse movement of any kind greater than 1° C. has not been recorded within the limits of twenty-four hours. These slow changes in the temperature of the soil would exert no stimulative influence upon the action of the roots. Thus, for instance, a sudden and great diminution of the temperature of a root temporarily would increase the rate of absorption which, however, soon begins to decrease again. The least daily variations occurred during the winter months, when it did not exceed (1° C. (1.8° F.).

It is interesting to recall in this connection some of my own observations on the temperatures of the roots of small herbs and grasses in Arizona which were growing in volcanic sand. The observations were made by mercurial thermometers in 1898, and it was found that these organs were carrying on their functions under temperatures as high as 44° C. (111 + °F.) to 45.5° C. (114 °F.).

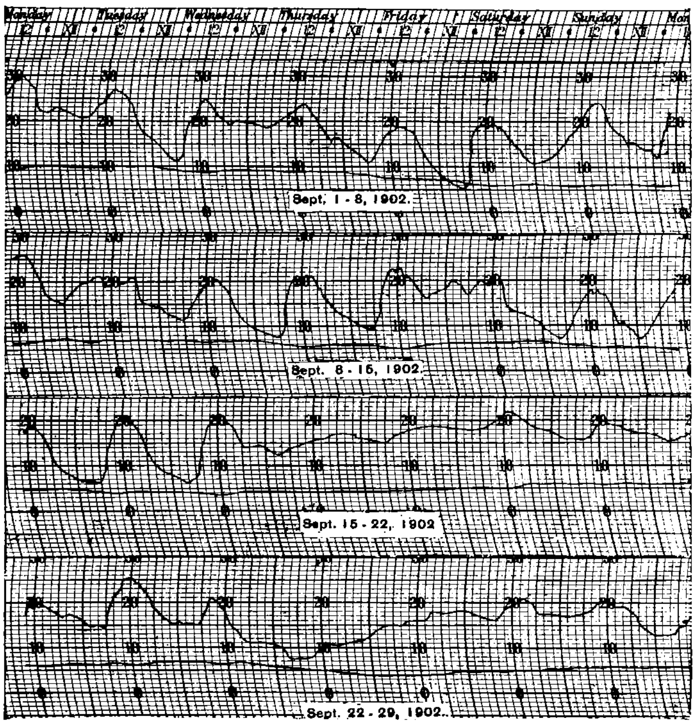

FIG. 5.—Tracings of thermographic curves of the air, and of the soil at a depth of 30 centimeters (1 foot), September 1–29, 1902. A general decrease in the temperature of the soil amounting to about 5° C. was shown. Centigrade scale. The temperature of the air is shown by the uppermost of each pair of tracings.

The general course of the temperature and the nature of the variations is shown by the accompanying tracings (see figs. 2 to 7) and the following data:

Temperatures of soil at a depth of 1 foot (30 centimeters) from June, 1902, to June, 1903 (degrees centigrade).

	1902.							1903.				
	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.
Maximum...	12.7	13.2	12.0	10.0	6.0	0.0	3.5	4.0	7.0	9.5	8.0	9.0
Minimum ...	7.6	7.5	7.4	3.7	—1.5	—2.5	—3.0	3.0	5.0	7.0	4.0	6.0
Variation ...	5.1	5.7	4.6	6.3	7.5	2.5	6.5	1.0	2.0	2.5	4.0	3.0

The maximum temperature for the year, 13.2° C. (56° F.), occurred in July, and the minimum, —3° C. (26.6° F.), in December, giving a total annual variation of 16.2° C. (29.4° F.).

When plants are cultivated in pots, in green houses, the small volume of soil around the roots responds much more rapily to changes in the temperature of the surrounding air and to the influence of streams and sprays of water than does the upper layer of soil in the open. In general the soil in the green house will show a much higher average temperature, which, with the other conditions mentioned, makes necessary special treatment on the part of the gardener. If the natural conditions of water supply by precipitation were complied with the needs of the plant would by no means be met under the altered conditions of temperature.

Not the least interesting feature of the records are the data concerning temperatures during the winter months when vegetation is supposedly in a resting condition. The first general drop occurs early in September when the temperature is lowered 5° to 6° C. (9° to 10° F.). A month later a second general downward movement was noticeable, in October, which reached the freezing point on October 22. After a few days fluctuation about this point a decrease began which reached the annual minimum of —3° C. (26.4° F.) on December 10. A heavy snowfall was followed by a steady rise which carried the temperature above the freezing point on December 15. The total period during which temperatures below the freezing point occurred included only fifty-four days, and the thermograph recorded freezing temperatures on but fifty days of this time. After the above date the rise was steady and continuous with minor fluctuations.

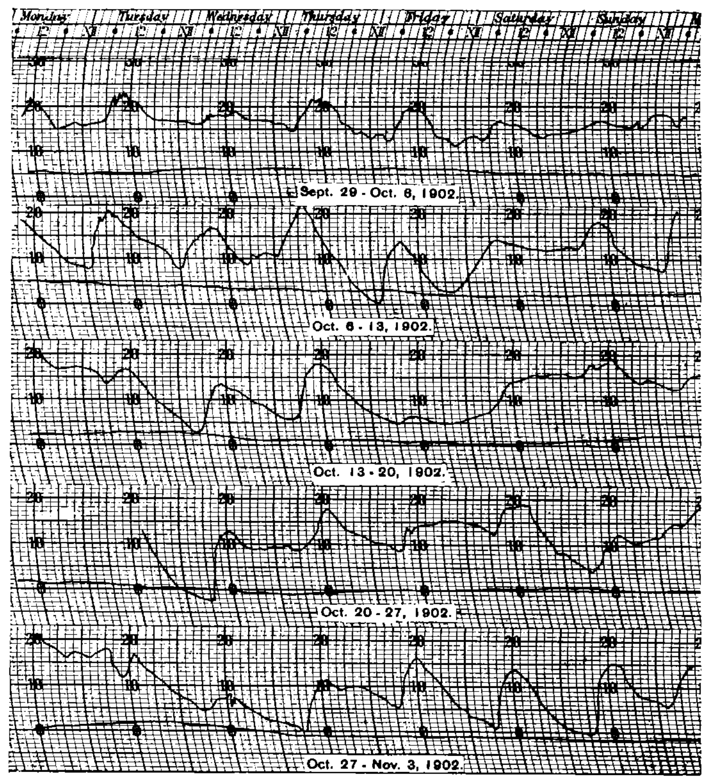

FIG. 6.—Tracings of thermographic curves of the air, and of the soil at a depth of 30 centimeters (1 foot), September 29–November 3, 1902. A further drop in temperature is shown which carries the soil below the freezing point temporarily on the 22d, and finally for the season on the 29th. Centigrade scale. The temperature of the air is shown by the uppermost of each pair of tracings.

Both the maxima and minima are higher in January than in December and are still higher in February, at which time the temperature of the air reaches its annual minimum. As a consequence of the above conditions the roots of plants at a depth of a foot (30 centimeters) in this locality find increasingly more favorable conditions for activity after the latter part of December. Growth and division of the cells, and the attendant respiration would ensue in many species at an accelerated rate over that prevalent in the earlier months of the winter and the absorption of mineral and other compounds could take place to the utmost capacity of the plant. This will still be more apparent when it is seen that the temperature of the soil at a depth of a foot is but little lower in February than it is in April or May at a time when the growth and formation of new organs in the shoot is at a maximum. The approach of the spring season in this locality therefore finds the root systems and absorbing organs of the vegetation which penetrates the soil to the given depth in a state of comparatively great activity, and it needs but the exposure of a few days or even of a few hours in some plants to allow for very marked development of the stems, leaves, and flowers.

Another point of interest in the present connection is the fact that such notable differences are found between the temperatures of the subterranean and aerial portions of the bodies of plants at almost all seasons. During June, 1902, the shoots of herbaceous plants were in an atmosphere that varied between 8° C. (46.5° F.) and 34° C. (92.5° F.), while the roots were between 8° C. (46.4° F.) and 13° C. (55.4° F.). As the maxima and minima were not synchronous the actual difference between the temperature of twigs and leaves on the upper part of the plant, and roots on the lower amounted to as much as 22° C. (nearly 47° F.) at certain times of the day. Such conditions occur, though slightly less accentuated, during the entire summer in this locality. It is evident without further discussion that such differences in the temperature conditions of the two poles of the plant must exert a more or less important influence on the transport of fluids and solutions from one part of the plant to another. Referring to the previous discussion concerning the comparative transpiration and absorption during the day it is to be seen that the heightened temperature of the shoot must operate in a simple physical way to greatly augment the amount of water thrown off while the roots must take in water at the same time to meet the loss at a temperature as much as 47° F. lower.

During the movement of the water from the roots to the leaves of grasses and other low growing plants, a total distance of no more than 50 centimeters (20 inches) may be traversed, occupying a matter of a few minutes, or an hour at most, during which time the temperature is raised the above amount. The warming of the liquid as it passes upward through the living and nonliving cells is attended by alterations in its solubility of mineral and organic substances and by a decreased capacity for holding gases in solution. The downward movement of solutions of sugars, acids, and nitrogenous substances from the leaves encounters the opposite set of conditions. This movement takes place almost entirely by osmose and diffusion and is a much more complicated process, both chemically and physically, taking place in living cells only. The cooling of the liquid would entail alterations in its power of carrying substances in solution and would also alter its physical relations to the atmospheric gases present.

It may be said, in conclusion, that the facts disclosed as to the actual temperatures in the soil, the diurnal and seasonal changes therein, and as to the differences in temperature of the aerial and underground portions of plants can not fail to be of very great importance in the physical and chemical processes, upon which growth, cell division, nutrition, and propagation depend. The determination of the effect of differences in temperature between the roots and aerial shoots has received but little consideration from the physiologist and the geographer. A careful analysis of the conditions and results of experimental observations carried on with plants under artificial conditions, with the roots and shoots under abnormally similar temperatures, would no doubt result in the detection of many mistaken conclusions, especially in regard to absorption, translocation, and transpiration.

That soil temperatures and the relations of these temperatures to those of the air must be of very great importance in the cultivation of economic plants is self-evident, especially in species in which the desired useful portion is formed underground and receives storage material formed by the activity of the aerial organs. Thus, in the case of such plants as the potato, certain mineral substances are absorbed from the soil at a comparatively low temperature, carried aloft into the heated leaves, where they participate in activities resulting in the formation of sugars, starches, and other carbohydrates, perhaps some nitrogenous substances as well, and then these complex bodies are slowly diffused downward, with many accompanying chemical and physical modifications, to underground cool storage organs, where a condensation occurs and the products are stored in insoluble form in the tuber.

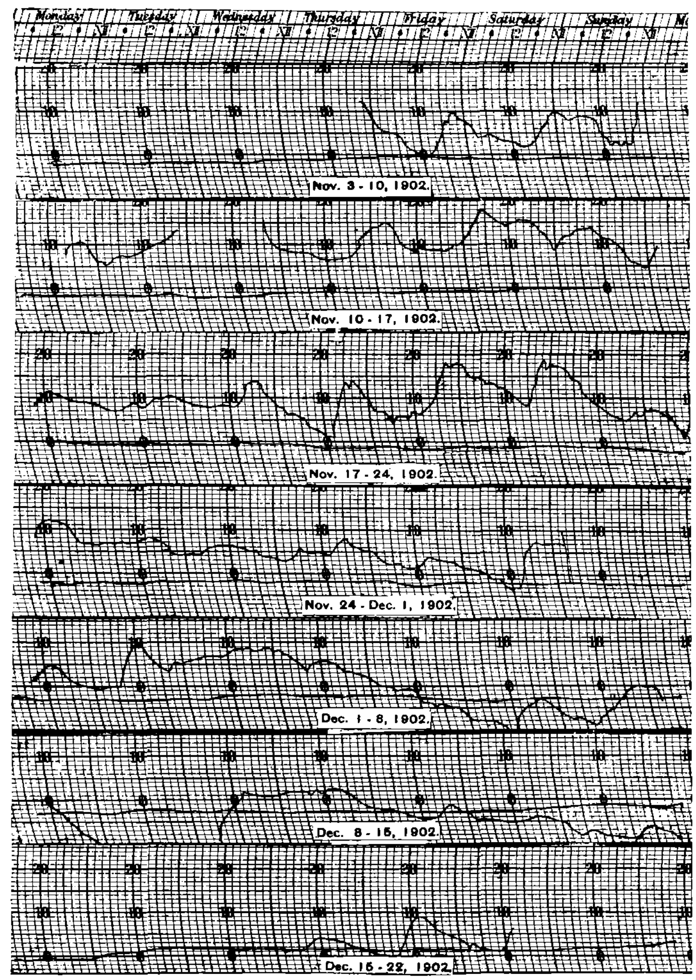

FIG. 7.—Tracings of thermographic curves of air, and of the soil at a depth of 30 centimeters (1 foot), November 3–December 15, 1902. The soil remained below the freezing point until December 8, when it began to rise steadily, and did not fall below freezing point during the remainder of the winter. Centigrade scale. The temperature of the air is shown by the uppermost of each pair of tracings.

NOTES AND EXTRACTS.

WEATHER BUREAU MEN AS INSTRUCTORS.

Mr. J. S. Hazen, Observer, Weather Bureau, Springfield, Mo., under date of August 1, incloses for inspection some manuscripts and charts covering a portion of the work done by him in the Drury College Summer School just closed. He states that he prepared eleven lectures in typewritten manuscript and also charts to illustrate them, and that these will probably be published in the series of articles in a leading newspaper of Springfield as a series for use in the winter schools. The work was undertaken at the request of Professor Childs for his class in physical geography. The class consisted of from ten to twelve teachers and the interest was such that they met twice a week at the Weather Bureau office, after office hours, during the summer school term of six weeks, usually taking an hour and a half for a lesson. A few members of the class