the wrong direction for so many years; the extensive and nearly simultaneous researches of Dr. Barus in the Geological Survey and Holborn and Wien in the German Reichsanstalt; and finally the successful return to first principles at the Reichsanstalt, with the help of the electric oven and the experience of the long line of distinguished predecessors, in which the speaker himself had a part.

The various methods for carrying pyrometric measurements beyond the range of the gas thermometer by making direct comparisons with it as far as it is available, and extrapolating the empirical relation thus obtained, were then taken up; Violle's calorimetric method, by which he obtained the results generally accepted for twenty-five years or more; the electrical resistance method (Siemens, Callendar and others), depending upon the variation in the resistance of a platinum wire with the temperature; the thermoelectric method (Barus, Holborn and Wien, and others), depending upon the electromotive force developed in a pair of wires (*pt* 90 *rh* 10—*pt* 10 usually) whose junctions are maintained at different temperatures; and several others. In closing, some recently published optical methods were reviewed (Berthelot, Lummer, Holborn and Kurlbaum) which promise to extend the upper limit of measurable temperatures almost indefinitely though with what accuracy, in view of the extent of the extrapolation necessary, it is hardly possible yet to say.

Dr. Day gave as the approximate limit of accuracy of the best methods now available $\pm 1°$ up to $1000°$, $\pm 10°$ to perhaps $1600°$, $\pm 100°$ to $3000°$ or more. He did not consider that the limit had been reached either in the accuracy or range of pyrometric measurement or even of gas thermometry and expressed regret that no more attention was being paid to so promising a field in this country.

Dr. L. A. Bauer presented a paper on 'Energy and Entropy: Their Rôle in Thermodynamics and Thermochemistry.' As suggested by the title, the respective rôles played by the two fundamental principles of thermodynamics, the principle of the conservation of energy and the principle of the increase of entropy, were set forth and elucidated by examples. It was shown that as much is known about the physical properties of entropy as of energy, and that in the phenomena of heat the entropy principle first comes into play, prescribing the direction or method in which stable equilibrium can take place. After the state of equilibrium has been reached then the principle of energy can be applied. It was shown that it would be a gain, now that the entropy function has been found, to discard the historical method of establishing the entropy principle and instead adopt a method similar to that followed by Hertz with regard to the fundamental equations of electromagnetism—*i. e.*, begin with an equation expressing a relation between the specific heats at constant pressure and at constant volume which admits of experimental proof and which prescribes that the entropy function has the same essential property as energy, viz., of being independent of the path or process used in going from one state to another.

A relationship between entropy and the term introduced by Helmholtz—*wärmegehalt*, changed by von Bezold to *potential temperature* and used by him extensively in his paper on the 'thermodynamics of the atmosphere,' was established and the name *entropic* temperature in place of *potential* temperature suggested.

CHARLES K. WEAD,
Secretary.

DISCUSSION AND CORRESPONDENCE.

AGRICULTURE AND THE EXPERIMENT STATIONS.

THE agricultural experiment stations of the United States, which the Federal Government has established in the several States, have now themselves passed the experimental stage and have to a remarkable degree won the respect and confidence of the farming and allied interests which it is their function to serve. There are at present fifty-nine experiment stations more or less completely maintained by Federal funds, two of which are colonial, and one of which is in Alaska. The organization and location of the continental stations affords an interesting example of the effect of the application of political conceptions to scientific investigation.

Agriculture is simply the business of growing plants and selling their products, either directly in the form of crops or indirectly in the form of the animal body into which they have been converted.

Affecting this are soil and climatic conditions, the market, the farmer's knowledge of the plants he grows and of the best methods for marketing their products.

None of these factors has anything to do with state boundaries. The fact that wheat is grown in a certain state is of no more, nor indeed of as much, significance as the fact that it is grown along a certain line of railway. A State boundary is a fiction of some political, but of absolutely no scientific importance whatever. A range of mountains or a river, on the other hand, is of tremendous significance so far as its effect on plant life is concerned. The northern and southern boundaries for a state like Kansas, two hundred miles wide, may be of some importance scientifically, as representing whatever differences in fauna or flora may be found resulting from the rather slight difference in the mean annual temperature of the two regions. But from the standpoint of scientific agriculture there is not a tithe of the significance in such a difference north or south from the center of this State as in the two hundred miles east or west of that point. Still more strikingly is the same fact exemplified in the states of Oregon and Washington.

The significant thing to know is not whether a given crop can be raised in the state of Oregon or in the state of Washington, but whether it can be raised in the region east of the Cascades, where there is a small annual precipitation and great evaporation, or west of the mountains where the reverse is true.

What does it convey to a scientific mind to say that such and such varieties of wheat are best for Ohio or Nebraska, when regional or climatic conditions within these states may furnish areas which demand wheat varieties of the most diverse character? Politically a state is a plane surface, holding a certain number of inhabitants subject to exactly the same civil laws.

Scientifically regarded, a state is an arbitrary block of territory chopped out at random, sometimes consisting of some vast physiographic domain of mountain, forest or prairie, sometimes comprising portions of all these within its imaginary boundaries.

One would naturally suppose that in the location of agricultural experiment stations, the points alone considered would be physiographic and meteorological ones. For scientific purposes, for example, one station in the western fourth of any one of those portions of the earth's surface called North Dakota, South Dakota, Nebraska or Kansas could more efficiently solve the problems of that whole vast region than can the present four stations, each of which is located outside of the high plains area, and in the eastern part of its geographic fiction, the state, which represents in each case in the eastern and western portions, such opposing facts of climate and topography.

One would naturally suppose that a geographical area of 62,000 square miles, of such very similar conditions as regards soil, climate and physiography as are found in the New England states, would scarcely need be provided with as many stations for experiment in agriculture as the region of 262,000 square miles which we call Texas, and which contains such diverse climates as are found in the humid tropical region of Brownsville, the desert tropical of El Paso, and the high, cool, semi-arid area of the Staked Plains. Yet we find six stations in the former and one in the latter geographic area.

The inconsistency involved in the absurdly unscientific location and distribution of our experiment stations is seen at a glance on a map of the United States having the stations prominently marked. Two stations dominating similar areas so far as agriculture is concerned, and of necessity dealing with precisely the same problems are found located ten miles from each other. But because they are in the separate 'states' of Idaho and Washington, it occurs to nobody to be an economic waste, as it certainly would if the neighboring boundary line were moved ten miles east or west, thereby throwing them into the same 'State.'

The location of stations within seventy miles of each other and in the midst of sim-

ilar areas impresses no one as useless, so long as it is known that one is in Wyoming and the other in Colorado.

This fundamental error involved in the establishing of one of the United States experiment stations in each state, regardless of the facts of climate, soil or physiographic aspect, which may make a unit of several states for the purposes of agricultural experiment or may subdivide one state into several wholly distinct areas so far as plant life is concerned, must necessarily be responsible for a lesser efficiency to the country in proportion to the number of stations established than would exist if locations had been settled upon by a committee of scientific experts, without any regard whatever to state boundaries.

In other words, the quasi-dual nature of the experiment stations, receiving as they do their support from the Federal Government while their allotment is to the states as such, to which are also left the direction and control of the experimental work, together with the appointment of their staffs, results in a regrettable lack of coordinated and economically directed work. It would seem that experiments in agriculture in the various agricultural areas of the country would be conducted to much better advantage, if all the operations of the Federal experiment stations were planned, directed and controlled directly by the Department of Agriculture at Washington. This, in fact, is the only way in which the faults of indirection and of duplication of work could well be avoided. Under the control of the Federal Government, the problems of each agricultural area could be assigned to such stations as were best fitted to deal with them, instead of their energies being distributed vaguely over a variety of subjects, more or less intermittently and at haphazard, as local influences or the curiosity of the individual investigators dictate.

One of the great difficulties with experiment station workers at present is the isolation in which they labor, and the limitations of their outlook upon agricultural problems in general, due to the intense localization of their work and thought. This cannot well be otherwise, as lack of funds precludes them from the travel necessary to gain a knowledge of the work of other experiment stations, and the conditions of other agricultural regions.

If the experiment station staffs were filled by civil service appointment from Washington, and a system of transfers from station to station and back to Washington were made possible, it would seem that the resultant increased breadth of view, and more comprehensive grasp of the problems of scientific agriculture would inure greatly to the benefit of the whole country. By such a system of transfers the right man to attack any given problem could be detailed, at any time, to any experiment station in the United States, while by a civil service system of appointments a constantly higher standard of efficiency than now prevails could be insured everywhere.

At the present time a tendency seems to exist, if one station makes a reputation for itself in any one line of experiment, for others in the neighborhood to be stimulated to emulate, and if possible to excel, its efforts, due to the influence of state pride or rivalry. A duplication of work here occurs which is often wasteful and useless.

Under a Federal system of control a given problem might oftentimes be divided and assigned in part to three or four stations working coordinately. The advantage of such an assignment in the case of many experiments is sufficiently obvious.

One of the difficulties in the way of the highest efficiency on the part of experiment station workers lies in the association of the experiment stations with the state educational institutions, and the combination of the duties of a teacher in one of these with those of an investigator in the experiment station. As a matter of fact, the work of the teacher and the investigator cannot be wholly divorced, but oftentimes by far the greater part of the time of the experiment station men is swallowed up in the details of college duties, to the serious detriment, of course, of the work of the station. The absolute separation of the federal station workers and the state agricultural college workers, so far as their duties are concerned, need not prevent the chemist

of the station from doing some teaching in soil chemistry for example, or the professor of botany of the college from taking advantage of the work and, so far as possible, sharing the interests of the botanist of the experiment station.

The main necessities then for the increased efficiency of our agricultural experiment stations would seem to be:

1. A centralized management, with the direction and distribution of all experimental work left to a single board of control, preferably to be connected with the United States Department of Agriculture.

2. A system of civil service appointments to positions in all Federal stations, and an elasticity in the organization of the different staffs, making possible the transfer of scientific workers from one station to another according to the judgment of the governing board.

3. The complete separation of the experimental research work of the station investigators and the pedagogical work of the college teachers of science in localities where the experiment station is located on the grounds of a state institution. This would necessitate an increased salary roll in both the college and station, but would increase the working efficiency of both in a far greater ratio.

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INJURIES TO THE EYE, CAUSED BY INTENSE LIGHT.

MR. FRANK ALLEN'S observations in these columns (January 17, 1902, p. 109) suggests an experience of my own which is worth recording in some detail.

Last April I ran the projection lantern one evening for a friend, the exercise lasting nearly two hours. The lantern is an arc lamp, hand feed, and the current was giving some trouble. The arc had to be kept rather short, and it was necessary to look in at the arc very often. To guard my eyes from the glare, I had three thicknesses of blue glass in front of the arc. Yet I noticed that my eyes were being injured. At the close of the lecture there was a distinct dimness in the center of my field of vision. This has often happened after looking at a bright light, and I thought nothing of it. Next morning, however, my neighbor at breakfast wore a bright yellow rose, and I noticed a distinct spot of pink on it, yet on examining it closely there was no pink, or at least only a trace of pink in the center of vision. At a distance of six feet the whole rose was pink.

On the street that morning, an orange peel on the walk at a distance of twelve feet was bright red; on a nearer view only a central spot was red. And every yellow house had a pink spot, and every orange surface a red one from that time on. Then I saw that in reading there was a gray area on the page in the center of vision.

It was plain that focusing so long on the arc through the blue glass had paralyzed or killed the cones in the *fovea centralis* and its immediate vicinity—that is, such cones as normally respond to the short waves at the blue end of the spectrum. So my eyes in that area of the retina responded only to the longer or red waves from the rose or the orange, and in ordinary vision I was deprived of just that much illumination.

This condition persisted in a very striking way all summer, but gradually disappeared in the autumn, and now, at the end of ten months, I can discover no trace of the dimness in the center of vision, nor can I see any trace of pink in a yellow surface. So whatever the disability was, it has been overcome. If the cones were destroyed, they have been replaced; and if only paralyzed, they have resumed their normal function.

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A GEOGRAPHICAL SOCIETY OF NORTH AMERICA.

TO THE EDITOR OF SCIENCE: Referring to the very interesting letter from Professor W. M. Davis (SCIENCE, XV., No. 373, p. 313, February 21, 1902), there seems to be no reason why the aims of the professional geographer should exclude any non-professional who is anxious to keep in touch with the latest advances in geographical knowledge.

Their need is apparently mutual. The pro-