the proposed wire screen to catch the fog is not an exact equivalent to the leaves and twigs of a given plant, and the relation between the catch of the screen and the catch of the natural plant must be an entirely uncertain matter, unless we can first, by special investigation, determine the ratio of the catches in the two cases. Moreover, this ratio must necessarily be an extremely variable quantity, depending on the velocity of the wind at the two locations and on the variations in the leaf surface as it increases and diminishes with the phenological season. Moreover, the surface will vary from year to year as the plant increases in size. It would, therefore, be difficult, if not impossible, to argue from the catch of a screen up to the catch of an orchard of trees. The rain gage tells us that there has been a half inch of rainfall during a dry month in the shape of drops that descended with sufficient rapidity and in sufficient quantity to sink into and really wet the soil, so that the roots of the plants could absorb the water. On the other hand this "fog depositor" simply tells us how much it collected, and gives no positive information as to how much the leaves and stems collected or how much of the water fell to the ground in such a shape and such a place that the roots could utilize it.

In the MONTHLY WEATHER REVIEW for October, 1898, and March, 1899, will be found several notes on the utilization of fog, but nothing that aspires to be called the measurement of the quantity of fog, such as is suggested in the above communication from Mr. Leonard. From these articles it will be abundantly evident that the fog may be gathered and made useful to the plant, not so much by a system of horizontal wires or wire network, as by a system of inclined wires, rods, or stocks, each of which serves to lead the fog as fast as collected directly down to that part of the ground where the roots of the plants most need it; in fact, down to the bottom of holes in the ground where the water will be absorbed and stored up for the use of the plant, safely protected from evaporation by the heat of the sun and the strong dry winds. If a field be covered with a system of such devices, each serving to furnish water for a special tree, then one such device, considered as a type of all, instead of watering a tree could be attached to a measuring apparatus, and we should thus know to what extent we were utilizing the fog, apart from the action of the tree itself. In fact, if one wishes, the drip from a given tree may also be measured, in order to know the relative value of the tree and the apparatus as collectors of fog.

It is much more important to stimulate the invention of apparatus to catch the fog and help the tree than it is to establish fog depositors and utilize their records in making up a respectable showing of total precipitation for the arid region. Over the whole world we find both arid regions, and plants that can be cultivated therein. Everyone knows that fog and dew are helpful in such regions. The main question is how to make the best use of them. It is, perhaps, a popular error to imagine that the dewdrops on the leaves are utilized directly by the latter. But we believe it has long since been definitely settled that aqueous vapor evaporates from the leaves and is not absorbed by them. The raindrops, dewdrops, and fog must be carried to the finest roots themselves and be absorbed by them before the water can become a part of the sap and the life of the plant. A foggy atmosphere represents a saturated or nearly saturated condition, such that the atmosphere, flowing by the leaf, does not stimulate evaporation from the leaf, but tends powerfully to the concentration of the moisture within. A too rapid evaporation from the leaf wastes the sap.

The cellular growth of the plant is a relatively slow process, and can not be greatly stimulated without injury to the resulting fruit or other products. But it may be greatly retarded by the scarcity of sap and the increased viscidity of this liquid, produced by an evaporation from the leaf more rapid than the sap can be supplied by the roots. This is shown by the limp and flaccid condition of the tender, green parts of plants under midday sun and dry wind, as compared with the coolness and dew or fog of the moist air during the nighttime. We apprehend that the benefits accruing to delicate plants from the presence of the daily fogs on the California coast result not so much from the drip of the fog caught by the leaves as from the protection offered by the fog against the burning sun's rays. In other countries we have seen similar protection offered by a thin layer of clouds, and in still others the injurious effect of the direct heat of the sun is greatly tempered by the cooling action of a very strong sea breeze.

THE FORMATION OF SNOW IN CLOUDLESS AIR NEAR THE GROUND.

By J. N. WEED, dated Newburgh, N. Y., May 16, 1904.

January 5, 1904, was an extremely cold day. The temperature ranged from 5° to 19° F. below zero.

Within a radius of 15 miles about the city some temperatures as low as —40° were registered. It was notably colder outside of the city than within.

For several hours in the middle of the day there was a gentle and continuous fall of snow flakes, forming about 40 feet above the surface in the middle portion of the street, and slowly falling (with a 10° deviation from the vertical, about,) and gradually increasing in size as they fell. The sky was clear and the air calm.

I went upon the roof to see if the snow was falling there or could be discovered in the air above. It was found to be confined to the street below the tops of the buildings. The windows were decorated with frostwork, showing the presence of vapor in the buildings at least. The street extends north and south parallel with the Hudson River, and is, say, about 25 feet higher and 300 feet distant.

Earlier in the morning there had been a fog haziness upon the water, limiting vision near the surface to half a mile, but this soon cleared away.

Can not an explanation of the snowfall be found in the very low temperature, in the excessive artificial heating of the buildings (which formed an unbroken row on both sides of the street), in the heating effect of the sun's rays on the sides of the buildings and on the flagged side walks (free of snow while the street proper was covered with ice), and last but not least by the escape of the moist, heated, dusty air of the buildings every time an ingress or egress took place? These conditions all tended to induce a rising current on the sides of the street and a falling one in the middle thereof. The rising current, on reaching the cornice of the buildings, was deflected outward and into the falling cold current and its vapor condensed.

One thing is absolutely certain: Snowflakes were formed under a cloudless sky, in the middle of the day, within 50 feet of the ground, in the narrow compass of a street but 50 feet wide.

Snow also fell on the following day under the same conditions, except a moderated temperature; less abundantly, however.

THE ENERGY IN A UNIT OF LIGHT.

By E. BUCKINGHAM, dated May, 1904.

Das mechanische Äquivalent der Lichteinheit: von Knut Ångström; Physikalische Zeitschrift *3*, 257, 1902.

Énergie dans le Spectre Visible de l'Étalon Hefner; par Knut Ångström; presented to the Royal Society of Sciences of Upsala, May 6, 1903.

The first of these papers is referred to by its author as a "preliminary note," and since it deals with experiments which form an integral part of the research described in the second paper, its contents will be described in this review of the latter paper, and need not be referred to separately.

The paper before us is divided into five sections, with the following headings: I. Introduction; II. General character of the radiation of the Hefner lamp; III. Distribution of energy in the visible spectrum of the Hefner lamp and the incandescent lamp; IV. Determination of the radiation of the Hefner lamp in absolute measure; V. The radiation in the luminous spectrum of the Hefner lamp, expressed as a function of the wave length.

In spite of the numerous researches that have been made, during the last few years, into the subject of the distribution of energy in the spectra of perfectly black and other radiating bodies, no such research has been made for the visible spectrum of any of our common photometric standards. Such a research has two objects: In the first place, a complete investigation of the visible energy curve of any given photometric standard will enable the future experimenter to investigate the distribution of energy in other visible spectra by spectrophotometric comparison, without having recourse to absolute measurements of energy. In the second place, it will enable us to determine to what degree the relations that have been established for black bodies hold good for the luminous spectra of our ordinary lamps.

The author defines the "visible spectrum" as that part of the complete spectrum for which $\lambda < 0.76\mu$, the energy in the ultraviolet being so small as to make it unnecessary to assign an inferior limit to the wave lengths included in the term "visible." The Hefner lamp used was a normal lamp of the Reichsanstalt form, made by Siemens and Halske; wick tube 0.8 centimeter inside diameter, 0.82 centimeter outside diameter; height above reservoir 3 centimeters; height of flame 4.0 centimeters. The radiation from this lamp, falling normally on an area of 1 square centimeter at a distance of 1 meter, constituted the unit of illumination, or meter-candle, to be investigated.

As a preliminary to the main research, the author compares the infra-red spectra of the Hefner and of an incandescent lamp, which he afterwards uses in some places as a substitute for the Hefner. The incandescent lamp (designed for a current of 0.25 ampere at 16 volts) had a straight filament, surrounded, except for a narrow rectangular opening on one side, by a blackened metal tube. On the side toward the opening in the tube the glass bulb was provided with a fluorite window. The filament was fine enough to permit of forming a fairly pure spectrum without the use of a slit. Infra-red energy curves were obtained by using the author's spectrobolometer.[1] It was found that for $\lambda < 1.50\ \mu$ the Hefner showed no emission bands and that within this region the incandescent lamp, when fed by a current of 0.21 ampere, had an energy curve whose ordinates bore an approximately constant ratio of 0.850 to those of the Hefner curve. A spectrophotometric comparison of the two lamps also showed the entire identity of their distributions of energy in the visible region, for this current strength, so that, later on, it was possible in the spectrum work to substitute for the Hefner the more convenient incandescent lamp.

The method used in investigating the distribution of energy in the visible spectrum may be outlined as follows: By two concave minors and a prism, the spectrum of the incandescent filament was formed. This could be cut off at any desired wave length by a movable screen. The remaining rays were recombined by a cylindrical lens, and allowed to fall on a bolometer, which thus gave the values, in arbitrary units, of

$$L_\lambda = \int_0^\lambda I_\lambda \, d\lambda,$$

where I_λ is the intensity for the wave length λ. By varying the wave length at which the spectrum was cut off by the edge of the screen, the variations of

$$\int_0^\lambda I_\lambda \, d\lambda$$

could be found; in other words, I_λ itself. The micrometer screw that moved the screen was calibrated by replacing the bolometer with a spectrometer, whose scale had already been calibrated in wave lengths, and noting, for various positions of the screw, the wave length at which the spectrum in the spectrometer was cut off by the edge of the screen. The correction for stray light was found by an ingenious process. In place of the bolometer, there was introduced a spectrometer with a double Vierordt slit and a rectangular eyepiece diaphragm. One-half of the slit received the rays which had passed the screen, and the other half those from a Hefner lamp, used as a comparison standard. By comparing the two lights for different positions of the screen and for different wave lengths, the ratio of the stray light to the total could be found and a correction applied to the bolometer readings. This correction nowhere amounted to more than 1.4 per cent. Tables are given showing the values of

$$\int_0^\lambda I_\lambda \, d\lambda,$$

for various values of λ, in terms of the bolometer readings, as well as tables of the same values reduced to absolute measure by means of the following experiments, which form the subject of the preliminary note referred to above.

This part of the work falls under two heads: *(a)* The total radiation, Q, of the Hefner lamp was determined by the Ångström's compensation pyrheliometer,[2] and it was found that at a distance of 1 meter

$$Q = 2.15 \times 10^{-5} [\text{gr. cal. sec.}^{-1} \text{ cm.}^{-2}].$$

(b) To determine $(L_{0.76} \div Q)$, the ratio of the luminous to the total energy, the mirror spectroscope and screen already described were used, the screen being set so as to cut off all rays for which $\lambda > 0.76\mu$. The bolometer was replaced by a photometer head, the other side of which was illuminated by a Hefner lamp so adjusted as to give equal illumination with the incandescent lamp. Thus, one side of the photometer received the total radiation from the Hefner, while the other side received a radiation which was optically the same, but contained none of the infra-red. By now substituting the bolometer for the photometer head, these two radiations were measured and their ratio found. The mean of 4 determinations gave

$$\frac{L_{0.76}}{Q} = 0.0096,$$

and on account of the difficulties of the work, the author fears that this result may possibly be as much as 4 per cent in error. The values of Q and of $L_{0.76}/Q$ being now known, the value of L for $\lambda = 0.76$ may be computed and we have

$$L_{0.76} = 20.6 \times 10^{-8} [\text{gr. cal. sec.}^{-1} \text{ cm.}^{-2}].$$

The use of this value makes possible the reduction of the values of L_λ to absolute units, as stated above.

The last section of the paper is devoted to a comparison of the results with some of the black-body formulæ. Since Wien's equation,

$$I_\lambda = C_1 \lambda^{-5} e^{-c_2/\lambda T},$$

[1] In this instrument the photographic plate, placed horizontally, is rigidly attached to the bolometer arm so that the synchronism is necessarily perfect. The spot of light from the galvanometer mirror is reflected so as to perform its motions in a vertical plane at right angles to the motion of the photographic plate. See Phys. Rev., 3, 137, 1895.

[2] In this instrument, two similar thermojunctions are attached to the backs of two similar, thin, blackened manganine strips. The radiation to be measured falls on one of these strips and heats it. The other strip is then heated to the same temperature—as shown by the thermojunctions—by passing through it a known current. By knowing the values of the current and the resistance, we find the energy needed to bring the second strip to the same temperature as the first; i. e., the radiant energy falling on the first strip.

is, for small values of λT, virtually identical with Planck's more complete equation,

$$I_\lambda = C_1 \lambda^{-5} [e^{c_2/\lambda T} - 1]^{-1},$$

the author has taken Wien's equation and, by the method of least squares, determined the constants in such a way as to give the best representation of his results for the Hefner lamp. The differences between observed and computed values do not appear to exceed the experimental errors. In these computations the temperature T is assumed to be constant, and the equation

$$I_\lambda = 0.0160 \lambda^{-5} e^{-7.85/\lambda}$$

is found to represent the distribution of energy in the visible spectrum of the Hefner lamp.

Using Paschen and Wanner's value, $c_2 = 14440$, for a black body, and the value 7.85 obtained here, the "black temperature" of the Hefner flame is computed to be 1830° absolute. This value agrees sufficiently well with the temperature of a candle flame which, from Lummer and Pringsheim's experiments, is found, by using the generally accepted equation

$$\lambda_{\text{max.}} T = \text{constant} = k,$$

to lie between 1960° and 1750°, on the assumption that for candle flame, k lies between the values it has for a black body and for bright platinum, respectively.

At the end of the paper are two plates showing the instrumental arrangements and giving a graphical representation of the results.

This piece of research is not only valuable in its result, as giving us some definite idea of the energy curve of a common photometric standard, which will enable us to investigate other luminous spectra by photometric methods. It is also a good example of a rather complicated piece of work ingeniously carried through, and it is both interesting and instructive. It is interesting to know that, in form at least, Wien's black-body equation is applicable to the Hefner lamp for $\lambda < 0.76\mu$. Ångström's computation gives 1830° as the temperature a black body must have to give a spectral energy distribution identical in the visible region with that of the Hefner lamp, and the radiating carbon particles in the flame are probably, for $\lambda < 0.76\mu$, pretty nearly black. It would be interesting to have some direct measurement of the temperature of the flame as a whole, and to see how much higher it is than the "black temperature." We may fairly assume that it is higher, because the solid carbon particles, radiating faster than the gaseous portions of the flame, would naturally be cooler; and in the main, at any rate, it is these particles for which we are getting a temperature when we work by radiation methods.

It is advisedly that we say *a* temperature and not *the* temperature. Any calculation of the temperature of a body which is based on radiation involves some assumptions, unless the same temperature has also, at some time or other, been measured by some better established scale; at least, if our calculated temperature is expected to have any meaning in terms of the more familiar scale.

METEOR OF SEPTEMBER 15, 1902.

By E. L. MOSELEY, dated Sandusky, Ohio, May 4, 1904.

September 15, 1902, a remarkable meteor passed northward over Ohio, Ontario, and Michigan. As it passed before daybreak few persons were up early enough to see it. According to a boy who was up early to carry papers, the meteor of September 15 fell into Sandusky Bay about a quarter of a mile from him and he "heard the splash." A man, 5 miles east of the city, said it was "about 75 feet above the ground" when it passed near him. An observer in Cleveland thought it fell into Lake Erie about 5 miles north of the city. Near Meadville, Pa., some workmen "saw it fall in the woods," and a Pittsburg paper undertook to give its weight. By extensive correspondence and the insertion of letters of inquiry in many papers I have learned that it was seen throughout northern Ohio, from Defiance to Ashtabula; in southern Ohio, in Pike, Perry, Morgan, and Washington counties; in western Pennsylvania, at Erie, Edinboro, and Meadville; in New York, at Westfield; in Indiana, at South Bend; in Ontario, at many places between Lake Erie and Lake Huron, also at Drayton and Arthur, east of Lake Huron; in Michigan, at Detroit, Port Huron, Ann Arbor, Lansing, and a number of other places in that part of the State; also in Osceola County about 240 miles west of Arthur, Ontario. So far my efforts to learn of observers in West Virginia or in Michigan north of Saginaw Bay have been unavailing. This, however, does not indicate that the meteor fell into Saginaw Bay, as observers south of that bay thought, or into the southern part of Lake Huron, as observers south of that lake thought. The weather map issued that morning shows cloudy sky at stations in the northern half of Michigan, also in a part of West Virginia, but over most of this portion of North America the sky was clear.

APPEARANCE AND SOUNDS.

The meteor passed over eastern Ohio and southwestern Ontario at about 5:42 a. m., eastern standard time. According to most observers it continued visible between ten and thirty seconds. It was egg-shaped or pear-shaped, with the large end in front. To many it appeared to have about half the diameter of the full moon, but was much brighter, giving probably several times as much light as the full moon. The color was like that of an arc light, white or with a slightly bluish or possibly purplish tinge.

At Waverly, in southern Ohio, a rumbling sound was heard, but correspondents in southeastern Ohio do not report any sound. At many places in northern Ohio sounds were heard, but not very loud. At Defiance, from which the meteor, when nearest, was 160 miles distant, four observers interviewed by Dr. C. E. Slocum heard "a hissing noise." An observer near Sandusky heard "a slight hissing noise about as loud as a bee." M. F. Roberts, directly under the meteor at Mentor, heard "a rushing sound," which also attracted his wife's attention.

In Michigan, E. J. Smith and W. Kearns, at Detroit, heard "a loud sizzling noise." Near Port Huron an observer reported by C. K. Dodge heard "a great crackling and hissing, supposing at first it was his stove."

In Ontario, Andrew Smale, of Union, compared the noise to "that of an electric car running." The noise was heard by a number of persons in and near London, Ontario. J. B. McMurphy says of the sounds, "first like the swish of a falling tree, then changing to a noise similar to the striking of a parlor match on some hard surface with not quite sufficient force to ignite it, but enough to make it snap. It was something like this—bir-rup-bir-rup-bir-rup, then changing to a sound like distant cannon. There were three such sounds as those. All those sounds were as if they had been produced from an echo and reproduced several times, each time growing fainter."

The greater intensity of the sound in Canada than in Ohio I suppose was due to the fact that the meteor was then moving through air not so rare as where it first became visible. The sound seems to have been no more noticeable directly under the meteor than many miles either side of its path.

DURATION AND EXTENT OF THE TRAIN.

The train left by the meteor was observed by many who were not up early enough to see the meteor itself. Geo. D. Berry, near Marietta, Ohio, estimated that it remained visible between five and eight minutes, but all observers farther north who kept watch of it give a longer time, quite a number giving fifteen minutes or twenty minutes or until daylight. C. K. Dodge, of Port Huron, who is doubtless correct, reports it visible there for more than half an hour. The Pontiac reporter