color, and the thousand other creatures of various size, up to the large octopus and the great edible turtle. The aquarium was intended to produce a revenue which should cover a considerable proportion of the expenses of the station, — an expectation which has not been fulfilled. Nevertheless, it is appreciated by all who visit it as a source of great delight and interesting knowledge, while it is indispensable to those who work in the station as a means of study and a reservoir of material.

Beneath the floor of the aquarium is a labyrinth of underground rooms, containing the engines, cisterns, and pumps by which the circulation of water is maintained throughout the tanks and the smaller aquaria in the laboratories above.

To the right of the main entrance to the public aquarium is a marble staircase, which the uninitiated are forbidden, in various languages, to ascend. It leads up to the part of the building devoted to scientific studies; and thus immunity is secured from all noise or disturbance. The naturalists at work hear only the breaking of the waves, or, at times, the sounds of music from the gardens, and the distant murmur of the city. On the northern side of this second story is the great laboratory, lighted by a row of windows twenty-five feet in height. It is fitted up for twelve workers; the tables, drawers, and shelves of each being so arranged as to form under a window a kind of alcove, which is thus well lighted from the north, and is fitted up independently with reagents and apparatus. Down the centre of the room is a long aquarium, consisting of two reservoirs, one above the other; so that, by means of siphons, circulation of sea-water may be kept up in the various vessels which the occupants of the tables use to isolate the animals they are studying, or to contain ova and embryos in course of development.

Besides this general laboratory, there are twenty small rooms fitted up for the same purpose, each provided with its own apparatus and aquaria.

The south side of the large laboratory has two windows opening on a central court lighted by a skylight in the roof, and extending down to the floor of the public aquarium, whose central tanks are arranged around it. A short bridge across this court leads to the library, which corresponds in size to the laboratory, and opens on to a spacious loggia running along the whole south side of the building. The library is well furnished and excellently lighted; and there is scarcely a work on any branch of biology, classical or recent, or any current scientific periodical of reputation, which is not to be found on its shelves. The height and fine proportions of the room are in keeping with the dignity of its function; and its walls are tastefully decorated with interesting frescos appropriate to the situation and character of the station.

To the west of the laboratory and library are the rooms where the material brought into the station is deposited, sorted, and distributed, and where the conservator, Salvatore Le Bianco, and his assistants, preserve specimens for the collection of the station, and for sending to distant laboratories or private investigators. In one of these rooms are the shallow tubs where the contents of the dredges are poured out, washed, and searched by a number of boys; and the variety of beautiful and interesting creatures to be seen here, everywhere around, produces an enthusiastic delight in the zoölogist on his first visit; and the impression is in no way lessened when he examines the exquisite collection of preserved specimens in Salvatore's room, and sees the most delicate and sensitive creatures — corals, alcyonaria, transparent medusae, and ctenophores — fixed in the fully expanded condition, and preserved in their natural shape. This result is obtained by a different method for almost every animal; and the successful treatment has been discovered, sometimes by a fortunate idea, but usually by patient and careful series of experiments.

THE SPECTRUM OF AN ARGAND BURNER.[1]

I HAVE been lately requested to determine the distribution of energy in the spectrum of an argand burner, and have been able to do this by means of the apparatus and methods previously employed at the Allegheny observatory for mapping the invisible spectrum of the sun. The results are curious; and, in the hope that they may also be found useful, I desire to communicate them to the academy. The difficulty in such a determination lies in the mapping of something which is wholly invisible; and it has not been made before, I presume, in spite of its economical importance, because there has been no means known of measuring this invisible energy, except in a rough way, by the thermometer or thermopile, by a process which gives incomplete results.

It was my object not merely to indicate

[1] Read before the National academy of sciences at its Washington meeting, April, 1883.

how much of the radiation from a gas-burner was visible, and how much was not, but to give a map of its distribution on the normal or wave-length scale, which would enable any one to see the quality and amount of the energy in each part of the light and heat region.

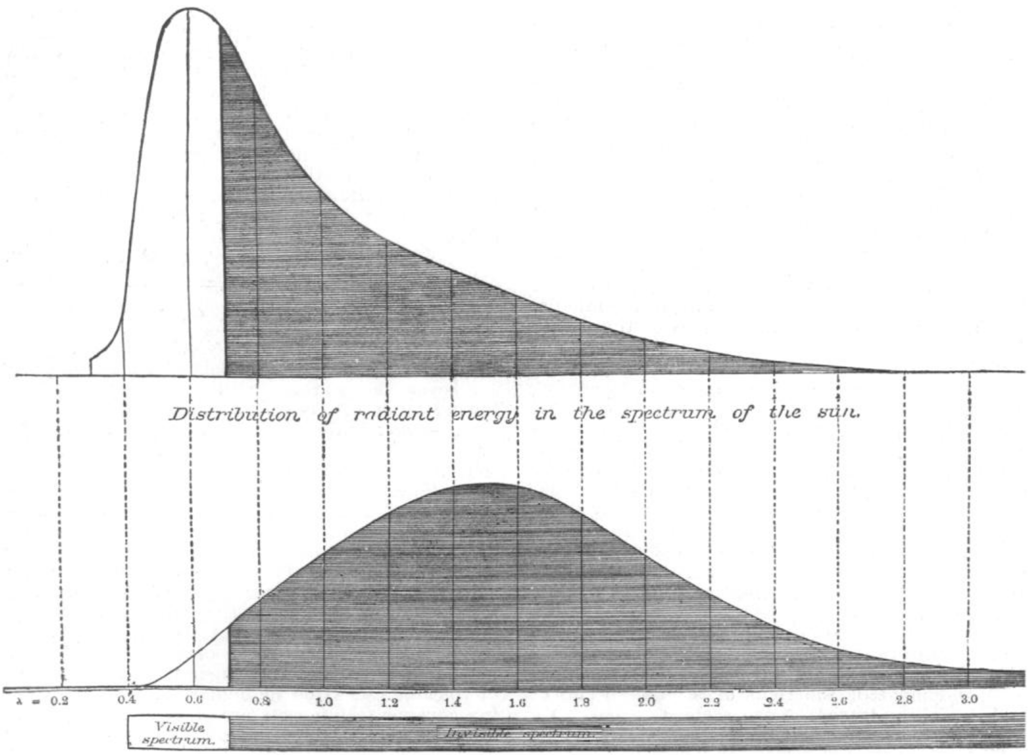
The ordinary argand burner, burning common house-gas within a glass chimney, was first placed at the centre of curvature of a large Rowland concave grating; and, by means of the bolometer, the heat was measured at successive points in the spectrum down to a wave-length of about .001 mm., where the overlapping second spectrum began to be sensible. Even in the preliminary determination, it was interesting to observe that the distribution of the heat was totally different from that in the sun, and that, instead of growing smaller, it grew greater, as the bolometer passed from the visible to the invisible end. As it was evident that the heat was still increasing at the point where the evidence from the grating failed, all the measures were next repeated with a prism of a special glass known to be transparent to the invisible rays. (It was first attempted to use the linear thermopile; but the heat was insufficient, and the linear bolometer was substituted.) With this, as many as thirteen ordinates were measured (representing the proportionate heat at as many points), their respective indices of refraction being determined by the known refracting angle of the prism and the observed deviations on the circle of the spectro-bolometer.

In a late communication to the academy, I gave the results of a recent research upon the connection between indices of refraction and wave-lengths, which enable us to deduce the normal spectrum (invisible as well as visible) from the prismatic one. It appeared to me when I was engaged in the first investigation, which to all but students of the subject must seem abstruse, that its results were of a kind which could never have much other than a theoretical interest: but it happens that this their first application is of a utilitarian character; for, having thus converted the prismatic values into corresponding ones on the wave-length scale, I was able to represent the conclusions from both by the normal maps which I now have here, and which exhibit the results of the analysis of the radiant heat which has come through the chimney. Let us remember that this radiant energy differs wholly in its qualities in different parts, and that the quality is shown by the wave-length number on the horizontal scale; the amount, by the height of the curve at that point. Near the part with wave-length .5 it gives the eye the sensation we call blueness, and near .7 it appears as a dull red, bringing very little light; at the point .9 or .10 it makes on the most sensitive eye no impression whatever, but has the power of passing freely through the glass chimney; near .3 the glass, so transparent to the light, is almost wholly opaque to the energy: so that each part has some quality peculiar to itself. By far the most important of these qualities, for our present purpose, is that of giving light. If we then analyze the radiant energy which comes through the chimney, the result is shown in our lower curve. The energy, which is what the gas supplies at the cost of the production from the coal, is for our present purpose regarded as saved or wasted, according as it is visible (light) or invisible (dark heat). The energy first becomes measurable in the blue, where there is very little of it, but where all there is, is effective as light; it increases steadily to the extreme red ordinarily visible where there is a great deal of it, but of a quality which is only interpreted by the eye as a dull reddish glow of little value for lighting; and then goes on increasing where it passes into complete invisibility, and still continues to increase as (for the present purpose) *pure waste*, till its maximum is reached at a wave-length of 1.5 or 1.6, — something like three times the length of the visible spectrum below the lowest visible ray. The energy at any point being proportional to the height, the entire radiant heat is proportional to the area of the curve. If we draw it on such a scale that this whole area equals 100, we can see the percentage expended in any kind of radiation at a glance. The small, nearly triangular area to the left of the line at .7, for instance, represents all the radiant energy useful as light; and this area being by measurement 2.4, while that of the whole curve is 100, we see that 2.4% are employed as light, and the remainder, 97.6%, are wasted. But this refers to the *radiant* heat alone, and takes no account of that expended in heating the air by convection currents. I have heard this latter estimated at three-quarters of the whole, but have not myself measured it. Admitting that this is approximately correct, however, it follows, that, since only one-quarter is radiated, it is 2.4% of this one-quarter only, which is light, and that finally less than 1 % of the whole is used, and more than 99% wasted.

It is instructive to take an amount of solar energy exactly equal to that we have just analyzed in the gas-burner, and notice how totally different it is in kind. The upper curve shows the distribution of such a small sample of the sun's radiation as shall be exactly equal to that from the argand burner. Of 1,000 parts of sun energy, 340 appear as light, and 660 as dark heat, if we take the dividing-line between light and darkness at the same point (wave-length 0.0007 mm.) in each curve. If we look at the quality of the light, the difference is enhanced. The

Similar curves obtained for the electric light would be interesting, but I have not undertaken them.

We are accustomed to indicator and other diagrams in the use of the steam-engine, showing us how our energy is being generated; but it is singular that so little has been done in the present direction in showing us with what economy it is being employed. I think interest attaches to these curves from a purely scientific stand-point, and they were made with no ulterior purpose. Yet in looking at them



Distribution of radiant energy in the spectrum of an argand gas-burner.

sun-curve attains its greatest height in the yellow, which here means that the energy is not only most efficient in making us see (that is, is most available as light), but that of this light the energy is again most effective in a part to which the eye is most sensitive, while, of the small amount of energy employed by the gas in making us see at all, most (as shown by the height of the curve in the dark red) is spent in rays to which the eye is not sensitive, and which give the gas its well-known inferiority in quality (of color) to sunlight, even where the quantity is the same.

I can but be so impressed with their utilitarian applications that I will ask leave to make a remark in conclusion with reference to this.

The gas-plant of this country is said to be some $30,000,000; and (except so far as it is used in heating) it appears from what has just been said, that it is mostly wasted as compared with the results possibly attainable, and in the sense that it does not realize one one-hundredth of what an ideally perfect lighting-agent might get from the coal now used. Though this ideal light will never be fully realized, it is undoubtedly possible to do what we see actually done in sunlight; and thus whoever can, without altering the quantity, effect this change in the quality of the radiation from gas, will add millions to the national wealth. S. P. LANGLEY.

THE NEW-YORK AGRICULTURAL EXPERIMENT-STATION.

THE weekly bulletins of the New-York experiment-station, although "intended to inform the public of progress at the station rather than to give complete results," nevertheless contain some matters of interest.

Seeds. — A series of weighings on light and dark colored seeds of several kinds showed, that, in every case, a hundred dark-colored seeds were heavier than the same number of light-colored seeds. The dark-colored seeds were also found to contain a larger percentage of seeds capable of germination. Sprouting-trials with onion-seed of different ages indicated that seed over two years old is of little value. Confirmation was obtained of the results of Will on the regermination of seeds, reported on p. 176 of SCIENCE. Out of a hundred kernels of corn, eight germinated for the fifth time after drying in the air. Both field-experiments and sprouting-trials showed a decided superiority, as seed, of corn taken from the tips of the ears over that taken from the butts or the middle.

Potato-culture. — The terminal eyes of the potato were found to germinate more promptly and vigorously than the basal eyes. The best crops were obtained, and at the least expense of seed, by cutting the potatoes to single eyes, and so cutting them that each eye retained a portion of the tuber extending as far as possible towards the central axis. Each eye may be regarded as the terminal bud of a branch extending from the central stem; and the potato should be so cut that each bud may retain all, or nearly all, of its branch. The conditions favoring the production of potatoes seem to be moisture and coolness for the roots, and warmth and dryness for the tubers. Culture which supplied these conditions, such as ridge-culture, and, still more, covering the seed-potatoes with four or six inches of sand, gave a large increase over level culture.

Root-development. — By excavation and washing, the development of the roots of several species of plants has been traced. Corn seemed to have two systems of roots, — one of fibrous roots, developing chiefly in the upper and warmer layers of the soil; and the other of coarser roots, passing downward into the subsoil. The hypothesis is advanced, that the former system serves mainly to supply the plant with ash ingredients, and the latter with water, and perhaps nitrogen. Wheat and potatoes appear to be deep feeders, developing their roots more abundantly in the lower and cooler layers of the soil. Tobacco, on the other hand, is a shallow feeder, like corn.

Feeding-experiments. — A single determination of the digestibility of corn-ensilage gave the following percentage results: —

Proteine	51.89
Fat	79.17
Crude fibre	60.91
Nitrogen free extract	67.59

The figures for proteine particularly are lower than those given in Kühn's tables of digestibility; and the conclusion is drawn, that the process of ensilage has decreased the digestibility of this ingredient. The conclusion is, however, entirely unwarranted; for the figures simply show that the ensilage was less digestible than Kühn's corn-fodder, but show nothing whatever about the digestibility of the corn-fodder of which this ensilage was made.

A series of feeding-experiments on milk-cows was carried out, the fat in the milk being determined chemically, while, at the same time, the butter obtainable from it was determined by actual churning. The interesting result was reached, that, with different rations, the amount of butter fluctuated much more than that of the total fat: in other words, the feeding seemed to make a difference in the completeness with which the butter could be extracted from the milk. A ration of shorts and hay gave the best results in this regard. Other interesting minor results were obtained, but the main object of the investigation is not very apparent from the account given in these bulletins. The coarse fodder was eaten *ad libitum*, the amount of water drunk was not regulated, and no sufficient data are here presented for a comparison of the different rations. It is to be presumed, however, that some of these deficiencies will be supplied in the formal report of the station.

An analysis of the milk of fatigued cows showed that it was quite phenomenal in character, the total solids being nearly a third greater than the normal amount, and the increase being nearly all in the fat.

H. P. ARMSBY.

CLASSIFICATION OF ISLANDS.

A. KIRCHHOFF (*Kettler's zeitschr. wissensch. geogr.*, iii. 169) presents some criticisms on Peschel's and Wallace's work in this direction, and proposes the following table. A, Festländische inseln: *a*, Abgliederungsinseln; *b*, Restinseln. B, Ursprüngliche inseln: *a*, Submarin enstandene vulkanische inseln; *b*, Aufschüttungsinseln; *c*, Nichtvulkanische hebungsinseln. The first group includes those derived from a continental land-mass, either by submergence or seashore erosion, the latter being uncommon. Its first subdivision (dismemberment-islands?) are found along the borders of existing continents, and are very numerous. The second subdivision (remnant-islands?) would include the last surviving summits of a drowned continent; but no examples are surely known, unless those of the Antarctic Ocean belong here. These continental islands might be of volcanic rocks, for the higher points of many existing continental districts are of volcanic origin: they are not necessarily of varied geological structure, as described by Wallace. Witness the monotonous low quaternary islands along the German seacoast. And, while it is true that land mammalia and amphibia are wanting on islands of the second group, it is an error to say, with Wallace, that they are always present on those of the first. Wallace recognizes that elevation, after a complete though short submergence, would reveal the island bereft of its earlier continental fauna, but finds no examples of such a result. Kirchhoff adduces the Halligen Islands of the North Frisian group as such examples; for their low surface is frequently submerged by high winter tides, leaving only the huts crowded on artificial mounds above water. They have no mammals (except the domestic); moles are unknown in their green meadows; nor have they toads or frogs. Larger examples of the first group are seen in Greenland and the archipelago north of British America; in the West Indies, once connected with South America, Florida being of comparatively modern extension towards Cuba; New Guinea; and Borneo.