upon the surface, the rule is that *the bands, or any parts of them, may be rubbed in the direction of the arrow.*

A good many surfaces have thus been operated upon; and although a fair amount of success has been attained, further experiment is required in order to determine the best procedure. There is a tendency to leave the marginal parts behind; so that the bands, though straight over the greater part of their length, remain curved at their extremities. In some cases hydrofluoric acid has been resorted to, but it appears to be rather difficult to control.

The delicacy of the test is sufficient for every optical purpose. A deviation from straightness amounting to $\frac{1}{10}$ of a band interval could hardly escape the eye, even on simple inspection. This corresponds to a departure from flatness of $\frac{1}{20}$ of a wave-length in water, or about $\frac{1}{30}$ of the wave-length in air. Probably a deviation of $\frac{1}{100}\lambda$ could be made apparent.

For practical purposes a layer of moderate thickness, adjusted so that the two systems of bands corresponding to the duplicity of the soda line do not interfere, is the most suitable. But if we wish to observe bands of high interference, not only must the thickness be increased, but certain precautions become necessary. For instance, the influence of obliquity must be considered. If this element were absolutely constant, it would entail no ill effect. But in consequence of the finite diameter of the pupil of the eye, various obliquities are mixed up together, even if attention be confined to one part of the field. When the thickness of the layer is increased, it becomes necessary to reduce the obliquity to a minimum, and further to diminish the aperture of the eye by the interposition of a suitable slit. The effect of obliquity is shown by the formula

$$2t(1 - \cos\theta) = n\lambda.$$

The necessary parallelism of the operative surfaces may be obtained, as in the above-described apparatus, by the aid of levelling. But a much simpler device may be employed, by which the experimental difficulties are greatly reduced. If we superpose a layer of water upon a surface of mercury, the flatness and parallelism of the surfaces take care of themselves. The objection that the two surfaces would reflect very unequally may be obviated by the addition of so much dissolved colouring matter, *e.g.* soluble aniline blue, to the water as shall equalise the intensities of the two reflected lights. If the adjustments are properly made, the whole field, with the exception of a margin near the sides of the containing vessel, may be brought to one degree of brightness, being, in fact, all included within a fraction of a band. The width of the margin, within which rings appear, is about one inch, in agreement with calculation founded upon the known values of the capillary constants. During the establishment of equilibrium after a disturbance, bands are seen due to variable thickness, and when the layer is thin, persist for a considerable time.

When the thickness of the layer is increased beyond a certain point, the difficulty above discussed, depending upon obliquity, becomes excessive, and it is advisable to change the manner of observation to that adopted by Michelson. In this case the eye is focused, not, as before, upon the operative surfaces, but upon the flame, or rather upon its image at E (Fig. 2). For this purpose it is only necessary to introduce an eye-piece of low power, which with the lens C (in its second operation) may be regarded as a telescope. The bands now seen depend entirely upon obliquity according to the formula above written, and therefore take the form of circular arcs. Since the thickness of the layer is absolutely constant, there is nothing to interfere with the perfection of the bands except want of homogeneity in the light.

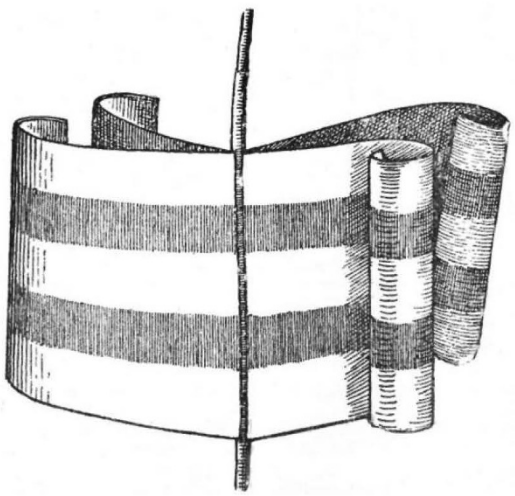
But, as Fizeau found many years ago, the latter difficulty soon becomes serious. At a very moderate thickness it becomes necessary to reduce the supply of soda, and even with a very feeble flame a limit is soon reached. When the thickness was pushed as far as possible, the retardation, calculated from the volume of liquid and the diameter of the vessel, was found to be 50,000 wave lengths, almost exactly the limit fixed by Fizeau.

To carry the experiment further requires still more homogeneous sources of light. It is well known that Michelson has recently observed interference with retardations previously unheard of, and with the aid of an instrument of ingenious construction has obtained most interesting information with respect to the structure of various spectral lines.

A curious observation respecting the action of hydrofluoric acid upon polished glass surfaces was mentioned in conclusion. After the operation of the acid the surfaces appear to be covered with fine scratches, in a manner which at first suggested the idea that the glass had been left in a specially tender condition, and had become scratched during the subsequent wiping. But it soon appeared that the effect was a *development* of scratches previously existent in a latent state. Thus parallel lines ruled with a knife edge, at first invisible even in a favourable light, became conspicuous after treatment with acid. Perhaps the simplest way of regarding the matter is to consider the case of a furrow with perpendicular sides and a flat bottom. If the acid may be supposed to eat in equally in all directions, the effect will be to *broaden* the furrow, while the depth remains unaltered. It is possible that this method might be employed with advantage to *intensify* (if a photographic term may be permitted) gratings ruled upon glass for the formation of spectra.

## FROST FREAKS.

MR. LESTER F. WARD describes some remarkable frost figures in the current number of *The Botanical Gazette*. He says that on a bright frosty morning in December, 1892, Mr. Victor Mason and himself observed some white objects looking like icicles close to the ground, along the border of a pine wood. A closer examination showed that they were in truth nothing but ice, but that instead of icicles they were veritable freaks of frost. Every one was firmly attached to the stem of a small herbaceous plant which had succumbed to the season but still stood erect. The attachment was always close to the base, often at the very ground, sometimes an inch above. At a distance, the frost-works had the appearance of cylindrical masses, but one need not come very near to see that such was not the case. In fact, they really consisted of several thin foils or wings from one to three inches in width, firmly attached by one edge to the stem of the plant, thus standing in a vertical position.



From this attachment each of these little ice sheets projected out horizontally or with a slight upward tendency, not straight and stiff, but gently and gracefully curving or coiling into a beautiful conch-like roll at the distal margin. There were always several of these, usually three, four, or five, all attached to the same vertical portion of the stem but at regular intervals around it like the paddles of a flutter-wheel, but all curving in the same direction after the manner of a turbine-wheel. Thus, where there were four they stood with each pair opposite, as in the figure, which represents a side view. The amount of curving varied considerably, and the coil filled up most of the interval between the plates giving the object a compact appearance. The ice was white, opaque, and singularly light, as if consisting of congealed froth, but in all cases the scrolls bore horizontal stripes like those of a flag, resulting from degrees in the whiteness, varying from alabaster to nearly transparent. These stripes added greatly to the beauty of these singular objects. In some cases the inner margin, instead of being straight, was sinuous,

giving a fluted character to the base of the wing. Many other peculiarities were noted in these evanescent toys, but they soon vanished.

But here is the chief wonder. There grew in the same situation some dozen or twenty small herbaceous plants of about the same general character which would all seem equally liable to exhibit such a phenomenon. There were species of Aster, Solidago, Chrysopsis, Pycnanthemum, Polygonum, Ludwigia, Sericocarpus, &c., and with these in considerable but not specially marked abundance, *Cunila Mariana*. The first frost-works seen were attached to this plant, which was supposed for a while to be an accident; but soon it was perceived that such was not the case, and an examination of hundreds of cases revealed the fact that they were exclusively confined to this species. No sign or semblance of them could be found on any other plant. They were, therefore, so far as observation went, a specific character, and it is this alone which prompted Mr. Ward to give the above account in the hope that others might be able to confirm or invalidate this induction by a wider one.

This plant persists after frost with all its branches, sere leaves, and empty seed vessels intact, so that its identity was as complete as in midsummer. The bark, which remained firm everywhere else, was seen to be longitudinally split into strips at the zone occupied by the frost-work, but as it could be seen between the several ice sheets, these rifts must have been covered by their bases. In other words, it cannot be doubted that the liquid matter out of which they were formed had passed through these longitudinal openings and been deposited by molecular accretions in the symmetrical forms observed. It was inferred from this that they might consist entirely of the juices of the plant, but on placing them on the tongue nothing distinguishable from pure distilled water could be detected. As the upper part of the stems was dead and dry and the roots perennial, the conclusion was that the water had by some agency been pressed or drawn up through the cambium layer of the roots from the soil and forced out through these apertures in the bark. The action of frost in the ground might account for the required pressure, and the whole would be thus explainable on physical principles. But it explains too much, since no reason can be assigned why the phenomenon should not be universal and not confined to a single species.

Since making these observations Mr. Ward has been to some pains to ascertain whether the phenomenon has been witnessed by others, but so far the inquiry has proved futile. It seems possible, therefore, that this is the first time that *Cunila Mariana* has been discovered to be a frost-weed. *Helianthemum Canadense*, however, behaves in a similar way. That plant is not common in the dittany and there has not been an opportunity to observe it at the proper season. The statement in the first edition of Gray's Manual, 1848, where the name "frost weed" is given to this species, that "late in autumn crystals of ice shoot from the cracked bark at the root, whence the popular name," repeated in all subsequent editions and copied into many other books, is doubtless founded on earlier recorded observations, but is not found in Nuttall or Pursh. A frost-figure also appears in Mr. Wm. Hamilton Gibson's recent book entitled "Sharp Eyes."[1] This figure is somewhat fanciful, being a vignette constituting the first letter of this chapter of his book and aiming to show all the parts of the plant in addition to the frost work. Although it is, according to this representation, a much less definite and less beautiful object than the dittany "frost-flowers," there can be no doubt that the principle on which it was formed is the same. The author's description of it as "fashioned into all sorts of whimsical feathery curls and flanges and ridges" indicates at once the inadequacy of his figure to do it justice, and the close analogy between it and the "frost flower" of Cunila.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

PROF. JEBB, M.P., in presenting the prizes and certificates on Tuesday to the students who successfully passed the last Cambridge local examination at Eastbourne centre, observed that thirty years ago examinations were believed to be a panacea for every educational defect. Now a reaction had set in, and some went so far as to hold that success in examinations afforded no trustworthy criterion of merit. The truth, of course, lay between these two extremes. An examination was not an infallible test, and was more favourable to some temperaments than to others; but, when well managed, was a sound test. An examiner must have at least three qualifications: he must know a great deal more than the subject in which he examined, or he would not have a proper sense of intellectual proportion and perspective; he must have a certain measure of acuteness to enable him to penetrate disguise or simulated knowledge; and, above all, he must have common sense in order to take proper account of particular circumstances of each case. The two older Universities, in the early part of the century, were said to be no longer in touch with the nation, and were regarded rather as great schools reserved for the education and, equally perhaps, the amusement of a select few; but now they had spread a network of examination, and were diffusing their influence over the country, becoming what they were in the Middle Ages, really national, but national in the higher sense, in the desire that every one who sought it should have the means of a liberal education, and that the best things which literature or science had to show should be placed within reach of all.

MR. ROBERT HOLT, late Assistant Lecturer in Engineering at University College, Liverpool, has been appointed Professor of Engineering at the People's Palace, London. Mr. Holt has held both Whitworth and National Scholarships, as well as one of the research scholarships founded by the Commissioners of the Exhibition of 1851.

AT a council meeting of the University College of Wales, Bangor, on June 21, a scheme for the supervision and residence of women students of the college next session was carried by a large majority.

LORD HERSCHEL has been appointed to succeed the late Earl of Derby as Chancellor of the University of London.

OXFORD has conferred the degree of D.C.L. upon Sir John B. Lawes, Bart., F.R.S.

## SCIENTIFIC SERIAL.

*Meteorologische Zeitschrift*, May.—Rainfall probability and cloud in the United States, by W. Köppen. The author has submitted the rainfall charts published by the United States Government to a thorough investigation. The following are the generalised results as regards the distribution of rainfall:—(1) There is a district of continental summer rains, enclosed on both sides by littoral winter rains, which, corresponding to the contrast of the yearly oscillation of temperature, are much more marked in the west than in the east. (2) A district of isobaric summer rains, in the south-east, with equatorial sea-winds in summer, and with anticyclonic weather in winter. (3) Transition districts, in which both rainfall maxima occur near each other, while the minima occur in spring and autumn. Maxima after the equinoxes are nowhere very well marked, but the April and May rains of Colorado and Kansas and the autumn rains on Lake Superior are indications of them. With regard to the seasonal distribution in the tropical zone, the differences of temperature play only a small part compared to that of extra-tropical regions; this result naturally follows from the small variation of temperature in the tropics.—On the dynamics of the atmosphere, by M. Möller. This first part deals chiefly with the causes of the inversion of temperature with height, and with the cold experienced in the centres of areas of high barometric pressure. He deals especially with three causes of inversion:—The cooling of the lower strata by radiation, the effects on the higher strata by dynamic heating or cooling analogous to those caused by the action of Föhn winds, and the transference of warm air to the higher regions by horizontal winds coming from warmer parts. Various cases are separately considered from data afforded by mountain stations, such as Ben Nevis, and from discussions by Dr. Hann and others. Particular attention is also given to the formation and motions of clouds, as furnishing visible evidence of the processes in action in the higher strata of the atmosphere.

## SOCIETIES AND ACADEMIES.

### LONDON.

Royal Society, June 8.—"Preliminary Report of the Joint Solar Eclipse Committee of the Royal Society, the Royal Astronomical Society, and the Solar Physics Committee on the

[1] New York, 1892. Article "The Frost Flower," pp. 210, 211.