Theoretical resolving power can only be obtained when the whole collimator is filled with light and further (as pointed out by Lord Rayleigh in the course of discussion during a meeting of the “ Optical Convention ” in London, 1905) each portion of the collimator must be illuminated by each portion of the luminous source. These conditions may be generally satisfied by projecting the image of the source on the slit with a lens of sufficient aperture. When the slit is narrow light is lost through diffraction unless the angular aperture of this condensing lens, as viewed from the slit, is considerably greater than that of the collimator lens.

When spectroscopes are used for stellar purposes further considerations have to be taken account of in their construction; and these are discussed in a paper by H. F. Newall.@@1 .

3. *Spectroscopic Measurements and Standards of Wave-Length,—* All spectroscopic measurement should be reduced to wave- lengths or wave-frequencies, by a process of interpolation between lines the wave-lengths of which are known with sufficient accuracy. The most convenient unit is that adopted by the International Union of Solar Research and is called an Ångström (Ȧ) ; and is equal to 10-8 cms. A. Perot and C. Fabry, employing their interferometer methods, have compared the wave-length of the red cadmium line with the standard metre in Paris and found it to be equal to 6438∙4696 Å, the observations being taken in dry air at 18°Cand at a pressure of 76 ems. (g=980∙665). This number agrees singularly well with that determined in 1893 by Michelson, who found for the same line 6438∙4700. Perot’s number is now definitely adopted to define the Ångström, and need never be altered, for should at some future time further researches reveal a minute error, it will be only necessary to change slightly the temperature or pressure of the air in which the wave-length is measured. A number of secondary standards separated by about 50 Å, and tertiary standards at intervals of from 5 to 10 Å have also been determined. By means of these, spectroscopists are enabled to measure by interpolation the wave-length of any line they may wish to determine. Inter- polation is easy in the case of all observations taken with a grating. In the case of a prism some caution is necessary unless the standards used are very close together. The most convenient and accurate formula of interpolation seems to be that discovered by J. F. Hartmann. If D is the measured deviation of a ray, and D0, λ0, *c* and *α* are four constants, the equation

λ=λ<>+(D-Do)1'∙

seems to represent the connexion between deviation and wave- length with considerable accuracy for prisms constructed with the ordinary media.

The constant *α* has the same value ι∙2 for crown and flint glass, so that there are only three disposable constants left. In many cases it is sufficient to substitute unity for *α* and write

λ=λθ+ D\_Do·

which gives a convenient formula, which in this form was first used by A. Cornu. If within the range 5ro0-3700 Å, the constants are determined once for all, the formula seems capable of giving by interpolation results accurate to o∙2 Å, but as a rule the range to which the formula is applied will be much less with a corresponding gain in the accuracy of the results.

Every observer should not only record the resolving power of the instrument he uses, but also the purity-factor as defined above. The resolving power in the case of gratings is simply *mn,* where *m* is the order of spectrum used, and *η* the total number of lines ruled on the grating. In the case of prisms the resolving power is—*t* *(dμ∣dλ),* where *t* is the effective thickness of the medium traversed by the ray. If ⅛ and t1 are thicknesses traversed by the extreme rays, *t*=*t2-t1*, and if, as is usually the case, the prism is filled right up to its refraction cap, *t1* = o, and *t* becomes equal to the greatest thickness of the medium which is made use of. When compound prisms are used in which,

for the purpose of obtaining smaller deviation, one part of the compound acts in opposition to the other, the resolving power of the opposing portion must be deducted in calculating the power of the whole. Opticians should supply sufficient information of the dispersive properties of their materials to allow *dμ∣dλ* to be calculated easily for different parts of the spectrum.

The determination of the purity-factor requires the measurement of the width of the slit. This is best obtained by optical means. The collimator of a spectroscope should be detached, or moved so as to admit of the introduction of an auxiliary slit at a distance from the collimator lens equal to its focal length. If a source of light be placed behind the auxiliary slit a parallel beam of light will pass within the collimator and fall on the slit the width of which is to be measured. With fairly homogeneous fight the diffraction pattern may be observed at a distance, varying with the width of the slit from about the length of the collimator to one quarter of that length. From the measured distances of the diffraction bands the width of the slit may be easily deduced.

4. *Methods of Observation and Range of Wave-Lengths,—*Visual observation is limited to the range of frequencies to which our eyes are sensitive. Defining oscillation as is usual in spectro- scopic measurement by wave-length, the visible spectrum is found to extend from about 770o to 3900 Å. In importance next to visual observation, and in the opinion of some, surpassing it, is the photographic method. We are enabled by means of it to extend materially the range of our observation, especially if the ordinary kinds of glass, which strongly absorb ultra- violet light, are avoided, and, when necessary, replaced by quartz. It is in this manner easy to reach a wave-length of 3ooo Å, and, with certain precautions, 1800 Å. At that point, however, quartz and even atmospheric air become strongly absorbent and the expensive fluorspar becomes the only medium that can be used. Hydrogen still remains transparent. The beautiful researches of V. Schumann@@2 have shown, however, that with the help of spectroscopes void of air and specially prepared photographic plates, spectra can be registered as far down as 1200 Å. Lyman more recently has been able to obtain photographs as far down as 1030 Å with the help of a concave grating placed in vacuo.@@3 Although the vibrations in the infra-red have a considerably greater intensity, they are more difficult to register than those in the ultra-violet. Photographic methods have been employed successfully by Sir W. Abney as far as 2o,ooo Å, but long exposures are necessary. Bolo- metrie methods may be used with facility and advantage in the investigation of the distribution of intensities in continuous or semi-continuous spectra but difficulties are met with in the ease of line spectra. Good results in this respect have been obtained by B. W. Snow@@4 and by E. P. Lewis,@@6 lines as far as 11,500 having been measured by the latter. More recently F. Paschen @@6 has further extended the method and added a number of infra-red lines to the spectra of helium, argon, oxygen and other elements. In the ease of helium one line was found with a wave-length of 20,582 Å. C. V. Boys’ microradiometer has occasionally been made use of, and the extreme sensitiveness of the Crookes’ radiometer has also given excellent results in the hands of H. Rubens and E. F. Nichols. In the opinion of the writer the latter instrument will ultimately replace the bolometer, its only disadvantage being that the radiations have to traverse the side of a vessel, and are therefore subject to absorption. In order to record line spectra it is by no means necessary that the receiving instrument (bolometer or radiometer) should be linear in shape, for the separation of adjacent lines may be obtained if the linear receiver be replaced by a narrow slit in a screen placed at the focus of the condensing lens. The sensitive vane or strip may then be placed behind the slit; its width will not affect the resolving power though there may be a diminution of sensitiveness. The longest waves

*@@@1 Monthly Notices R.A.S.* (1905), 65, p. 605.

*@@@2 Wied. Annalen* (1901), 5, p. 349.

*@@@s Astrophys. Journ.* (1906), 23, p. 181.

*@@@4 Wied. Αnnalen* (1892), 47, p. 208.

*@@@6 Astrophys. Journ.* (1895), 2, p. 1.

*@@@\* Drude Annalen* (1908), 27, p. 537 and (1909), 29.