radiation; but the electric energy may equally well be directly converted into the motion of radiation. As a fact, we have never yet been able to obtain either the emission or the absorption spectrum of hydrogen without the aid of an electric current, so that, in reasoning on this spectrum, we are much more in a region of speculation than when treating of flames. Whether the hydrogen lines, bright or dark, in the solar spectrum are produced directly by the high temperature of the sun, may even be called in question. And though we may admit that the density of the hydrogen in the sun's atmosphere, outside the photosphere, is but slight, it does not follow that the total pressure of all the gases forming that atmosphere is so very small as Messrs. Frankland and Lockyer ('Roy. Soc. Proc.,' vol. 17, p. 288) have, from the width of the lines, concluded it to be. After all, it is not so easy to connect the temperature, even of a flame, with its radiation, for it is only when the condition of a gas is steady that we can assume that there is a definite relation between the motion of agitation, on which temperature depends, and the vibratory motions, on which radiation depends. In speculating on such questions, chemical, as well as electrical, changes must not be lost sight of, although the latter may be more directly concerned in radiation.

Experiments which we have commenced upon the arc in an atmosphere of compressed gas tend to the same conclusion. It does not appear that the metallic lines in the arc are sensibly affected by a steady pressure up to 15 atmospheres. The details of these observations, which are complicated by the variation of resistance with change of pressure, we defer until the experiments are finished.

III. "On the Focometry of Lenses and Lens-Combinations, and on a new Focometer." By Silvanus P. Thompson, D.Sc., B.A., Professor of Physics in the City and Guilds Technical College, Finsbury. Communicated by Professor G. Carey Foster, B.A., B.Sc., F.R.S. Received February 4, 1891.

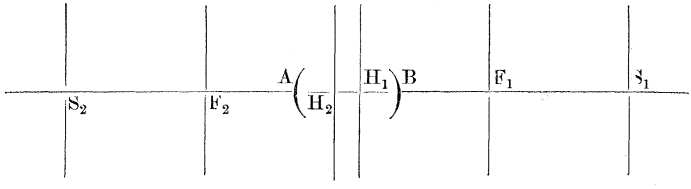
(Abstract.)

Few of the accepted methods of focometry take into account the distance between the two principal points (or Gauss points) of a lens, or afford the means of measuring this distance, as well as the true focal length, and some of them are open to the objection that they necessitate troublesome double adjustments. Of these methods the author gives a brief categorical review.

He has devised a method in which there are no double adjustments, no measurements of the size of optical images, no assumptions as to

the approximate positions or distance apart of the two principal points, but in which both the true focal length and the width between the principal points are determined by direct measurements of lengths.

The principle of the method is as follows:—Beyond the principal focal points on each side of the lens, at distances equal to the true focal length, are two points which are conjugate to one another and symmetrically situated at twice the true focal length from the two principal points. These may be called the symmetric points: and the planes drawn through them orthogonally to the principal axis may be called the symmetric planes. They are planes of unit magnification, and possess the known geometric property that the ordinate in one of these planes of the point of intersection of any incident ray is equal in magnitude, but opposite in sign, to the ordinate in the other plane of the point of intersection of the emergent ray. Let AB be the lens or combination of lenses, F_1F_2 the principal foci, H_1H_2 the principal points, S_1S_2 the symmetric points. Then the true focal length is $F_2H_2 = F_1H_1 = F_1S_1 = F_2S_2$.



Suppose a parallel beam to be sent from left to right through AB; an image will be formed at F_1. Let the light then be sent from right to left forming an image at F_2. Suitable transparent micrometers are placed to receive these images and to ascertain their precise position in space. A graduated bench is provided upon which the lens and the micrometers are placed so as to read off the distances between these points. A gearing is provided, namely, a right- and left-handed screw, by means of which, when the two micrometers have been placed at F_1 and F_2 and clamped to the screw, they can be moved by the experimenter at exactly equal rates outwards, so that when one arrives at S_1 the other arrives at S_2. This is known by observing in one micrometer the exact image of the other of equal size. The distance through which the micrometers have each been displaced is equal to the true focal length; and the distance H_1H_2 between the two principal points is found by reckoning backwards from F_1 and F_2 distances equal to the focal length so found. The positions of the two principal points can then be marked upon the outside of the tube of the objective.

These principles are embodied in an instrument described in the

paper, and called a *focometer*. It has been constructed to the author's designs by Messrs. Nalder Brothers, to whom sundry of the mechanical details are due.

The paper also describes the results obtained with the focometer upon various lenses, some of them being microscope objectives, others camera lenses. The author finds in several of these lenses that the principal planes are crossed: the distance between the symmetric points being less than four times the focal length. In some other lenses which are achromatic in respect of bringing all rays to a common principal focus, the positions of the principal planes are different for rays of different colours. In one lens, a microscope objective by Reichert, the principal planes are not only crossed but are actually at a greater distance apart than the two principal foci. The paper is accompanied by a sheet of full-size drawings showing the construction of the instrument and its details.

IV. "The Numerical Registration of Colour. Preliminary Note." By Captain W. de W. Abney, C.B., R.E., D.C.L., F.R.S. Received February 6, 1891.

The Committee of the Royal Society on Colour Vision having put into my hands the determination of the colour of certain signal glasses, a memorandum was drawn up on the method of the numerical registration of colours and submitted to them. They considered that it should be submitted to the Royal Society, and having slightly modified it, it is presented as a preliminary note of a part of a paper which will be subsequently submitted by General Festing and myself as Part III of "Colour Photometry."

It must be premised that a colour is determined when its hue, its purity, and its luminosity are known, the last constant being its comparison with the white light before its passage through a transparent coloured body, or with white light reflected from a white surface if it be an opaque coloured body such as a pigment.

There has hitherto been a certain amount of difficulty on the part of normal-eyed persons in stating the exact hue of compound colours in terms of any standard; in fact, I believe, except by the method given in the Second Part of "Colour Photometry" ('Phil. Trans.,' A, 1888), there has been no exact means indicated of reproducing a colour from measurements made. The method which will be described can take the place of the previous plan for certain purposes, more particularly when it is the impression on the eye which has to be considered. Any colour can be reproduced from the registration numbers with the greatest exactness.

To persons who are totally colour-blind to one sensation, viz., the