"On Flame Spectra." By Charles de Watteville. Communicated by Arthur Schuster, F.R.S. Received May 28,—Read June 16, 1904.

(Abstract.)

In order to obtain the spectrum of any substance, it has generally been considered sufficient to introduce a small quantity of it into an already formed flame. In the course of a photometrical investigation of flames which had been coloured by injecting the spray from saline solutions into the gas to be burnt, M. Gouy discovered in the spectra of the flames several new lines belonging to the metal contained in the solution.* Instead of appearing throughout the whole flame, as did the previously known lines, these new lines were only emitted in the vicinity of the inner blue cone—the origin of the Swan spectrum. The observations of M. Gouy were limited to the examination of certain lines of the visible portion of the spectrum, and, with the advice of Professor Schuster, and under his direction, I have taken up this study with the object of extending it, by means of photography, to the ultra-violet portion of the flame, and also of detecting lines which are too feeble to be visible to the eye.

The method employed for the production of the flame is, in short, that which has been introduced by M. Gouy, and described by him in his memoir, to which reference should be made for a description. The very slight modifications which have been made in the apparatus of this scientist are due to the necessity of having an arrangement which should be as automatic as possible during the 8 hours which were often found necessary for the photographic exposures. These modifications, however, have an important bearing upon the success of the experiments.

The spectroscopical apparatus used has been of two kinds—a fine Rowland concave grating of 1-metre radius and prism spectroscopes. The results obtained by means of the grating have been completed, as regards the very weak lines, with the help of the prism spectroscope.

The lines in the spectra obtained under the conditions of my experiments are very much more numerous than is the case when all the portions of the flame do not participate in the production of the phenomena. Not only are all the lines present which were seen by Professor Hartley in the oxy-hydrogen blowpipe flame, but, in addition, there are a large number of other lines which only extend to the height of the blue inner cone. Moreover, the flame spectra extend sufficiently far into the ultra-violet in order to enable the line 2194 of tin to be observed.

If we compare the flame spectra thus produced with those of the arc and the spark, it will be noticed that, as a rule, the lines which are

* 'Annales de Chimie et de Physique,' 5th Series, vol. 18, 1879.

found in the flame spectrum are those which are the strongest lines in the arc spectrum. In certain cases, some of the more intense arc lines are absent, whereas less intense arc lines are to be found in the flame spectrum. On the other hand, none of the characteristic lines of the spark spectrum are ever seen in the flame spectrum. The resemblance, however, is very marked between the flame spectrum and that of the spark which has been made oscillatory by the introduction of a self-induction into the discharging circuit of a condenser. In the latter case, as is well known from the work of Dr. Hemsalech, the spark spectrum is considerably simplified.* Moreover, although the flame spectrum will contain only the lines which belong to the spectrum of the oscillatory spark, yet all the lines of the latter will not be found in the flame spectrum, the missing lines being those which are peculiar to the ordinary spark spectrum, and which only exist in the immediate neighbourhood of the electrodes, becoming shorter and shorter, and finally disappearing as the self-induction is increased.

The preceding paragraph refers to metals other than those belonging to the iron group. On the contrary, there is a most striking similarity between the flame spectra of iron, of nickel, and of cobalt, and the oscillatory spark spectra of the same metals in the region included between about 4300 and 2700 Ångström units. The similarity of the two spectra is so great that, except for very small differences of intensity, the oscillatory spark spectrum, which is photographed as a comparison spectrum in the centre of the flame spectrum, appears to be a prolongation of the latter. It should be noticed that if in the visible portion of the spectrum certain lines appear to be missing, it is doubtless because the continuous spectrum prevents these feeble lines from being seen. This explains why M. Gouy was not able to observe the nickel lines which are found on the photographs taken with various salts of nickel, viz., the sulphate, chloride, and ammoniacal chloride. In the ultra-violet the spectrum of the flame appears to fade away a little more rapidly than that of the oscillatory spark, but it is probable that this difference would be reduced by prolonging the time of exposure; since it is, of course, the radiations of the shortest wave-length which are most absorbed by different media.

It is very probable that the reason for this similarity between the spectrum of the flame and the spectrum of the oscillatory spark is entirely a question of temperature. On the one hand, the increase in the number of lines of the flame spectrum obtained by the use of the sprayer may be attributed to the fact that the hottest regions of the flame take part in the production of the phenomena, and, on the other hand, the diminution in the number of lines in the spark spectrum when the spark becomes oscillatory is due to a diminution of its temperature.

* 'Sur les Spectres d'Etincelles.' Paris, Hermann.