PROFESSOR MENDELÉEFF ON THE HEAT OF COMBUSTION.[1]

DULONG'S formula, which gives the heat of combustion of different solid and liquid fuels, as depending upon their composition, is, as is known, $\phi = 81\,c + 345\left(h - \frac{o}{8}\right)$, c, h and o representing the percentages of carbon, hydrogen, and oxygen in the fuel.

If a general expression, $\phi = Ac + Bh - Co$, be taken, the numerical value of the coefficient $A = 81$ must be maintained, because it corresponds to pure charcoal, and all known data (from 8140 to 8060) prove that the figure 81 must really be taken for each per cent. unit of carbon in the fuel (the accuracy of the measurements being within the limits of from 1 to 2 per cent. of the total heat of combustion). For hydrogen, however, the coefficient $B = 345$ cannot be maintained, because it has been obtained out of data relative to the burning of gaseous hydrogen, while in usual solid or liquid fuel the elasticity of the gas is lost; its hydrogen must be considered as if it were liquefied, and consequently B must not be, according to what is known, more than 300 (admitting, as is usually done, that the water obtained during combustion is in a liquid state).[2]

In order to find the true coefficients suitable for practical purposes, Mendeléeff took the figure $\phi = 4190$, which is quite correct (within 1 per cent.) for pure cellulose, as also the average from 79 most complete measurements for fat coals (by Maler, Alexeyeff, Damski, Diakonoff, Miklaschewski, Schwanhöfer, and Bunge), and the average for naphtha fuel, and he has found:

$$\phi = 81\,c + 300\,h - 26\,(o - s),$$

which formula represents,[3] with an accuracy of from 1 to 2 per cent., the heat of combustion of pure charcoal, coke, coals, lignites, wood, cellulose, and naphtha fuels; of course, it applies to the best determinations only, especially to those which were made in a calorimetric bomb, where the error is less than 1 to 2 per cent.[4]

This formula is an approximate empirical expression of facts; but it corresponds at the same time to the numerical value of the coefficient B for hydrogen, which could be expected from theoretical considerations.[5]

1 Translated from the *Journal* of the Russian Chemical and Physical Society, vol. xxix. fasc. 2, 1897, pp. 144. (Minutes of meeting of February 18, 1897.)

2 Maler has also adopted that coefficient, taking $C = 30$.

3 The percentage of sulphur was not determined in each measurement, and consequently the coefficient $+ 26$ is determined only approximately.

4 If the water which is formed during combustion is represented, as it is in reality, in the shape of steam, then 600 *aq* must evidently be deducted from ϕ; *aq* representing the weight of water obtained from the combustion of one unit of fuel.

5 In those cases where different values of ϕ were received for the same composition of coal, the discrepancies could be explained by errors of measurements; there was no foundation to suspect isomerism. A good deal of the now prevailing incertitude is also due to the incomplete data relative to the amount of combustible sulphur.

THE SCIENTIFIC REQUIREMENTS OF COLOUR PHOTOGRAPHY.

ON Tuesday evening, June 1, in the Examination Schools, Oxford, Captain W. de W. Abney, C.B., F.R.S., gave the sixth Robert Boyle Lecture before the Oxford University Junior Scientific Club. The President, Mr. R. A. Buddicom, was in the chair, and about 800 members and their guests were present.

The subject chosen by Captain Abney was "The Scientific Requirements of Colour Photography." The following is an abstract of the lecture:—

Colour photography and photography in natural colours are two distinct methods of arriving at the same end, namely, the production of a picture of objects, coloured as they naturally appear to the eye. Both have been accomplished and depend on the application of science, but in the case of the former additional knowledge is requisite of the mode of action of the retina and of theories of colour vision.

In colour photography the theory of colour vision usually adopted is the Young-Helmholtz three-colour theory, in which red, green and blue are selected as primary colours, and not the red, yellow, blue of the artist. Captain Abney pointed out the difference between colour and colour sensation, and placed his colour sensation curves before the audience. These curves enable particular coloured screens to be selected, so that if transparencies from three photographs of the same object, taken one through an orange screen, one through a green, and one through a blue, be each illuminated by its own peculiar coloured light, and the three images be superimposed, the effect is to reproduce a picture of the object in its original colours. The colours of the screens used for taking the negatives must not be such as to allow only monochromatic light to pass. Thus the red screen must allow some orange, the green some yellow, and the blue some green, so that the lights through the three screens overlap somewhat.

The viewing screens, on the contrary, should be as nearly monochromatic as possible. By these means Mr. Ives has, in his chromoscope, been able to present to view photographs of natural objects in the colours in which they appear to the eye.

The next process described was that of Dr. Joly, of Dublin, who, basing his work on the same theory of colour vision as Mr. Ives, reproduces in colour by means of a single negative. This method is essentially founded on what may be called a happy imperfection of the eye. The human eye is incapable of separating points which lie very close to one another. In an engraving, the black lines, close together on a white surface, blend with the white surface to form shades of grey. Dr. Joly's method is to rule lines 1/200 inch broad on a transparent screen, touching one another and being coloured alternately red, green and blue. The lines are of such a depth of colour that the mixture, if made by rotating sectors, would appear white or grey. This screen is used for viewing. To make the negative another exactly similar screen is placed in front of the plate, but the colours of the lines on this differ, just as Mr. Ives' coloured screens for taking the negatives differ from his viewing screens.

When the negative is taken, a transparency is made from it, and the viewing screen is placed behind it, so that the red line covers the place through which the orange negative was taken, and so on. Then, and not till then, the picture appears in its natural colours.

Instead of using transparencies and coloured films, transparent inks may be used to produce pictures by three printings.

The next process described was the oldest, namely, the production of colour by the action of light itself. The present year is its jubilee. Becquerel found that if, instead of iodising a plate, he chlorinised it, and then exposed it to white light, it gradually assumed a violet tint, and if, in this state, he exposed it to the spectrum he was able to obtain the colours of the spectrum on it.

Abney, some years ago, showed that the red tint was due to the lavender-coloured material taking up oxygen, whilst at the violet end the subchloride became further reduced: thus the big molecules formed by the addition of the oxygen vibrated slower, whilst the abstraction of chlorine gave smaller ones vibrating quicker. Since he was able to get the same effect on collodion plates, it is not probable that the colours are due to stationary waves, because, if so, they could only be viewed by reflected light. Unfortunately, however, these colours, from the very manner in which they were produced, were not permanent, and no method has been devised for fixing them.

The last method Captain Abney described of obtaining photographs which showed colour, but not coloured photographs, was that of Lippmann, who found that if, by means of reflection, he obtained stationary waves in the film, on development the silver was deposited between the nodes. On reflecting light from such a "noded" plate, the proper light alone was reflected, and the photograph, viewed at a particular angle, appeared in its natural colours. If looked at by transmitted light, these photographs have merely the appearance of ordinary negatives.

The proceedings closed with a vote of thanks to the lecturer, proposed by Prof. Burdon Sanderson, and seconded by Mr. A. F. Walden.

THE INTERNATIONAL CONGRESS ON TECHNICAL EDUCATION.

THE International Congress on Technical Education, opened by the Duke of Devonshire at the Society of Arts on Tuesday, June 15, was continued on the three following days. Many important papers were read, and there was a large attendance of delegates from the continent and abroad. We have extracted from the *Times* the subjoined brief reports of a few of the papers read and the discussions which took place upon them.