

and E is Young's modulus. Hence by determining m and E and also by measuring the changes in thickness of a stressed plate, the sum of the principal stresses may be evaluated as an average throughout the thickness of the plate. Having obtained the sum and difference, it is a simple matter to state the values of p_r and p_t separately. A new form of instrument is described in the paper, specially devised for measuring small changes in thickness of a stressed plate. This instrument is partly optical, readings being obtained by means of a ray of light reflected from a mirror which is rotated partially by the strain to be measured. One millimetre on the scale is equivalent to two millionths of an inch change in the lateral dimensions of the specimen. A number of experimental determinations are given in the paper and show very concordant results.

COLLOIDS AND THEIR VISCOSITY.

SPECIAL interest attached to the meeting of the Faraday Society, held on Wednesday, March 12, in view of the distinguished foreign guests who took an active part in the proceedings. These included Prof. Pauli (Vienna), Dr. Wolfgang Ostwald (Leipzig), Prof. Victor Henri (Paris), Prof. Freundlich (Brunswick), and Prof. Nernst (Berlin).

The meeting took the form of a symposium upon colloids and their viscosity, and the afternoon session was opened by Dr. Wo. Ostwald, who, in an introductory address of a general character, showed the importance of viscosity measurements as a means of study of the colloidal state. In the course of his remarks, which were fully illustrated with examples, he laid special stress upon the need for kinetic, as opposed to static, methods for the investigation of heterogeneous systems, and in this connection also emphasised the value of viscosity measurements. An illustration of this principle was immediately afforded by the communication of Profs. Freundlich and Ishizake on the rate of coagulation of $Al(OH)_3$ -sols as measured by the viscosity change, the results of which were in complete accord with those of Paine upon copper oxide-solutions, using a totally different method. The following empirical formula proved to express the experimental results of coagulation by potassium salicylate with great exactness:—

$$dx/dz = 2Kz(1+bx)(1-x)^2,$$

where K is a constant depending on the concentration of the electrolyte, z represents time, and x the amount of precipitated particles, the latter taken as proportional to the increase in viscosity. From the equation in its more general form,

$$dx/dt = K_1 f(U)(1-x)^2,$$

Freundlich and Ishizake drew the following conclusions. The term $(1-x)^2$ suggests the coagulation process to be primarily a reaction of the "second order" in which the colloidal particles may be supposed to unite in pairs, the cause for which union is to be found in an asymmetry of their electric charges (expressed in the term $f(U)$) due to unequal degrees of electrolyte-adsorption. The degree of asymmetry was found to be proportional to the time z , to the number of precipitated particles, and to an exponent of c , the concentration of electrolyte thus:— $f(U) = \lambda c^q z(1+bx)$, where λ , q , and b are constants.

Prof. Pauli directed attention to the importance of viscosity measurements in the study of "emulsoid" colloids in a survey of the chief results obtained in his own school, showing what important generalisations as to the ionisation and degree of hydration of proteins in solution had been arrived at by this means. His experiments proved, for example, that at the iso-

electric point, where, by definition, the ionisation of the protein is a minimum, a close correlation existed between that property and (1) osmotic pressure, optical rotation, viscosity, and imbibition of water, all of which reached their lowest value, and (2) precipitability by alcohol which was at its maximum. With increase in concentration of protein ions, caused by addition of either acid or alkali, a corresponding rise was found to occur in the value of the first set of properties and a fall in the precipitability.

The evening session was chiefly devoted to a discussion of the factors concerned in the viscosity of colloidal solutions and the interpretation to be placed upon the viscosity value. Mr. Emil Hatschek developed a mathematical theory of the viscosity of two-phase systems, showing that for "suspensoid" equally with "emulsoid" colloids, viscosity depended upon the volume-ratio of the two phases, and was independent of the size of the colloidal particles. In the case of the former, as shown also by Einstein and Bancelin, the viscosity increased in linear ratio with the volume of disperse phase, while in the case of "emulsoid" colloids the viscosity of the system was equal to

$$\frac{\sqrt[3]{A}}{\sqrt[3]{A}-1}, \text{ where } A = \text{ratio: } \frac{\text{volume of system,}}{\text{volume of disperse phase}}$$

the viscosity of the continuous phase being taken as unity. Experimental support was adduced in both instances, and interesting confirmation also obtained for the above formula in the case of paraffin soap-solution emulsions, where viscosity had been determined by means of Couette's apparatus, and direct measurement could be made of the volumes of both phases. Prof. Henri gave a critical survey of the various direct and indirect methods available for volume-measurement of colloidal particles. He showed that, among the indirect methods, that of Perrin (based on the distribution with depth of colloidal particles after settling), and that of Rayleigh (by measurement of the intensity of light after lateral diffusion through colloidal solutions) were among the most trustworthy, since in the formulæ used for calculation of r , the radius of the colloidal particles, the term r was raised to the third and sixth power respectively. As a result of work with $Fe(OH)_3$ -sols Prof. Henri, expressed the view that apart from the question of phase-ratio, or size of colloidal particles, the arrangement of the latter might have a very important influence upon the viscosity of the system.

An interesting discussion followed, in which, among others, Dr. Ramsden, Dr. S. B. Schryner, Dr. McBain, and Dr. C. J. Martin took part. In the absence of the chairman, Dr. R. T. Glazebrook, the chair was taken by Mr. Emil Hatschek.

ATMOSPHERIC HUMIDITY AND TEMPERATURE.

TWO papers on the psychrometer formula, reprinted from recent Proc. Roy. Soc., Victoria (vols. xxiv. and xxv.), discuss a modification, proposed by Dr. Ekholm, of the Stockholm Meteorological Office, to be made in Regnault's formula for the wet- and dry-bulb hygrometer, which would have important consequences if confirmed. The formula so modified would be $x = \eta f - AB(t-t')$, where x and f are respectively the actual vapour-pressure and the saturation vapour-pressure at the temperature t' of the wet bulb. A is the ordinary psychrometric constant, and η the coefficient, less than unity, inserted by Ekholm to allow for a supposed diminution of vapour-pressure at the surface of the wet bulb due to hygroscopic action of the material covering it. The first paper, by Dr. E. F. J. Love

and Mr. G. Smeal (Government research scholar), dealt with temperatures near the freezing point, and the second, by Mr. Smeal, dealt with temperatures up to 31.4°C . The discussions appear to have proved that the suggested coefficient, being so nearly unity, is not wanted, especially if the covering be thin muslin and be kept clean. The factor, $A=0.00072$, derived from the observations and careful computations, varies slightly according to wind force. In the event of any modification of the simple formula being accepted it might be in this sense, but we suggest that it would be more to the point if one formula were selected from among those which already exist, and be recommended for general adoption.

A useful paper on the wet-bulb thermometer and tropical colonisation, by Prof. J. W. Gregory, F.R.S., is published in the *Journal of the Scottish Meteorological Society* (vol. xvi., No. xxix.). The author points out that the view that the tropics are injurious to health is prevalent, but the explanations why this is so are very unsatisfactory. Heat is mostly regarded as one of the principal factors of tropical maladies, but it is now recognised that no locality with a *dry* climate has a temperature so high as to be injurious to health; in fact, the hottest districts in a country are often the healthiest. Healthiness of tropical localities does not depend upon diurnal or annual range of temperature, and moisture is not necessarily injurious; the latter is better for some constitutions, but heat and moisture combined may be very harmful. Experiments appear to indicate that "the industrial development of any locality where the wet-bulb temperature commonly exceeds 80° will be almost, and if it exceed 88° , quite impossible." But statistics supplied to the author by the Meteorological Office show that such high wet-bulb temperatures do occur in well-populated tropical localities. The author laments that the distribution of such temperatures is not well known, and refers to the collection of observations in Australia by Prof. W. A. Osborne, of Melbourne. The annual summary of the Australian Monthly Weather Report for 1910 (received by us in July, 1912) contains monthly wet-bulb isotherms from 9h. a.m. observations, with means of 80° in the north-west in December-February inclusive.

RECENT ADVANCES IN SCIENTIFIC STEEL METALLURGY.¹

IT has already been pointed out that the year 1870 marked the commencement of the tungsten era, and 1880 that of the tungsten-chrome era. But the years 1899 to 1902 inaugurated what is destined to be the most remarkable epoch of the three, namely the vanadium era. During these years was carried out in the experimental steel works of Sheffield University a series of researches on the influence of the comparatively rare metal vanadium on plain carbon steel and on alloy steels. At that time (1899) vanadium was 60s. per lb. In 1912, owing to the large demand, the cost had fallen to 10s. per lb.

The first report, having reference mainly to cutting steels, was issued in June, 1900, and the second and third reports respectively in January and June, 1902. The results are briefly summarised in the two next paragraphs.

June 28, 1900.

"The results of this preliminary investigation have profoundly impressed upon my mind the future before vanadium as a steel-making element, and even at this early stage of my knowledge of its effect, I venture

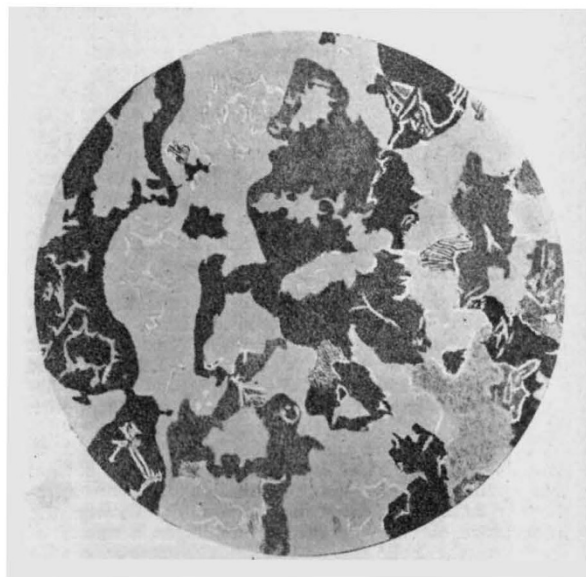
¹ Discourse delivered before the Royal Institution on Friday, January 24, by Prof. J. O. Arnold, F.R.S. Continued from p. 49.

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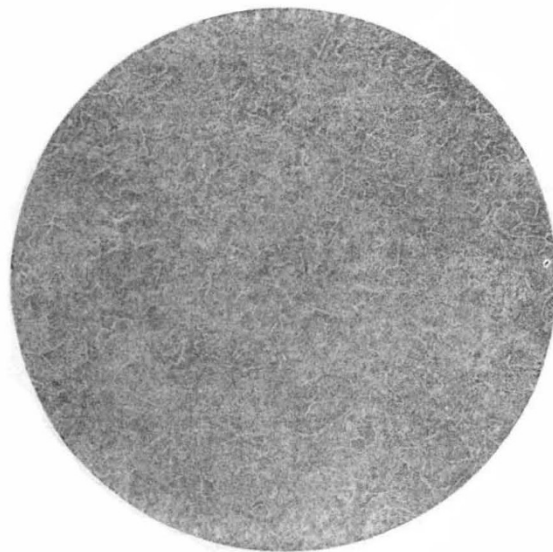
to say that its action resembles that of tungsten, but that it is from ten to twenty times as powerful as the latter element."

January 14, 1902.

"It is already evident that as a steel-making element vanadium will place in the hands of metallurgists and



(a) Carbon, 0.60 per cent. Vanadium, 0.71 per cent. Pale ground mass of slightly vanadiferous ferrite. Dark areas, troostitic vanadium pearlite. Less dark areas, sorbitic vanadium pearlite. White cell walls and masses, "B" iron cementite, resulting from thermal decomposition of laminated iron pearlite, a few areas of which still remain undecomposed.



(b) Carbon, 0.93 per cent. Vanadium 5.84 per cent. Ground mass of sorbitic vanadium pearlite, overlaid with a broken and irregular mesh-work of vanadiferous ferrite.

FIG. 6.—Magnified 450 diameters.

engineers a very powerful weapon, because it is now demonstrated beyond doubt that the addition of a few tenths per cent. of vanadium raises the elastic limit of mild structural steel at least 50 per cent., without seriously impairing its ductility or presenting any difficulty in the hot or cold working of the steel."