ments on the plates were not exactly radial, which he took to mean that they were not due to gravity, but to some irregular refracting medium. He further said that Einstein himself regarded the shift of the solar spectral lines as vital to his theory.

Prof. Lindemann and Dr. Jeffreys agreed in thinking that the experiments were by no means decisive against the existence of the spectral shift. The latter further stated that a medium capable of producing the observed shift of the stars by refraction would reflect a great deal of sunlight, whereas the plates showed no trace of such matter near κ Tauri.

FLOTATION PRINCIPLES OF ORE EXTRACTION.

AT the meeting of the Institution of Mining and Metallurgy, held on November 20, a paper entitled "A Contribution to the Study of Flotation" was presented by Mr. H. Livingstone Sulman. After giving a brief historical review of the development of flotation as applied to ore extraction, with the problems that arose in connection with successive phases of the process, Mr. Sulman dealt principally with froth flotation, which he characterised as the final link in a long chain of effort. The essentials of this process are that an aqueous pulp shall be agitated with certain reagents which may be classified as a "froth-producing" material, a "froth-stabilising" substance, and a "gangue-modifying" addition.

The explanation of flotation may be based on the differences shown by various substances in the degree to which they are "wetted" by water and other liquids. "Wetting" is a condition of wide variability, and a theory of flotation must be based largely upon the physics of wetting. The degree of wetting may be influenced by the molecular porosity of the solid surface, and indicated more or less quantitatively by the "contact angle" made between the free surface of the liquid and that of its interface with the solid.

Reviewing the various problems encountered in dealing with flotation, Mr. Sulman devoted considerable attention to the molecular constitution of liquids and solids, gravitation and molecular forces, surface energy and surface tension, interfacial tension which involves consideration of the effects of complete wetting and differential wetting, hysteresis, adsorption, the *rôle* played by immiscible oil, and the action of modifying agents such as acids. In this last connection the theories of flocculation and deflocculation have to be taken into account, including their electrical relationship. Film flotation and differential flotation receive separate attention.

The general summary of the paper gives prominence to the following findings:—Flotation reactions result from the molecular forces acting at the surfaces of solids and liquids; these arise from unbalanced molecular attractions in the surface layers, which in turn are in functional relation to the balanced molecular attractions constituting cohesion for a solid or a liquid. Every solid or liquid, therefore, possesses excess energy at its surface, which may be exhibited in adhesion effects. Liquid-solid adhesion is broadly reciprocal to interfacial tension. The degree of wetting can be relatively quantified within certain limits by the contact angle made between the free surface of the liquid and that of the solid. Contact angles have a minimum and a maximum value; the angular difference between these values is the hysteresis of the contact angle, which permits a wider range of equilibrium for a floating particle.

The dynamical aspect of the subject is concerned with the molecular constitution of the interfaces, with the kinetic effects of molecular motion at the surfaces and interfaces of solids and liquids, and with those in the interior of liquids. Solid surfaces are probably penetrable by the molecules of liquids, which enhances the adhesions between them; such penetrations may give rise to a persistent tendency for the solid to be again wetted by the same liquid. Concentration of foreign molecules at the surface of a pure or homogeneous liquid (positive adsorption) reduces the surface tension of the liquid and confers upon it the property of "frothing."

Frothing reagents useful in flotation produce a froth with water, yet leave a partial strain (mineral-adsorptive energy) at the bubble surface. The mineral adsorption now stabilises the film, especially if the mineral be minutely oil-filmed; still more so if flocculated. To be employed effectively the bubble system must be disseminated throughout the mass of ore-pulp. When water-strain is completely removed from the surface of suspended particles, deflocculation results. Flocculation is greatly increased by mechanical agitation, by minutely oiling the particles, and by contact with air; these are factors necessary to produce standard mineralised froths. Generally, if a substance can be flocculated it can be floated. Electrical phenomena are concomitants of minor order. Flotation depends on bringing about the most advantageous selective adhesions, selective adsorptions, and selective flocculations between the complex of particles in an ore-pulp.

THE BRITISH ASSOCIATION AT BOURNEMOUTH.

SECTION L.

EDUCATIONAL SCIENCE.

OPENING ADDRESS (ABRIDGED) BY SIR NAPIER SHAW, LL.D., Sc.D., F.R.S., PRESIDENT OF THE SECTION.

Educational Ideals and the Ancient Universities.

A PRESIDENTIAL address before the Educational Section of the British Association is an undertaking that might fairly daunt the bravest of those who are really acquainted with its difficulties. The vast range and variety of the problems of education; the enormous amount of effort that is already expended upon them; the torrents of advice and criticism that are offered by those who are familiar with the details of the various curricula, who know how things ought to be done—if I had had time and capacity to become acquainted with all these things, I suppose I must have avoided the duty of making an address. It is, perhaps, the detachment of my present position from any responsibility for details which gives me the courage to recall experiences, now twenty years old, acquired during a lengthy service in various capacities at Cambridge, and matured by twenty years of the consciousness of the dire need of educational discipline and training for those whose business it is to use science in the service of the State.

With a certain amount of assurance I can even be glad that I am not in touch with the educational controversies of the hour, and confidently trust that my deficiencies will be made good by the contributions of those who know to the discussions which will take place in the Section, but the difficulty that I cannot get over just now is that, from the unavoidable circumstances of the present time, a presidential address is a "back number" before it is delivered, for the simple reason that, according to tradition, it must be printed in advance. In this particular year there is an almost immeasurable gulf of experience between the time of my appointment in 1917 and the delivery of this