arms of old Americans with those of other peoples. In some other sections as, for example, in that dealing with the head, averages and distributions are afforded not only for the whole data but for different states and comparative frequency polygons for different sections are given. Thus the work becomes a valuable hand-book of comparative anthropology of all races and pedigrees of different sections of the United States.

Of the care with which Dr. Hrdlička has worked there can be no doubt, as his technique is known to be excellent. A slight difficulty is introduced in the very nature of his subjects which has made it necessary to take the measurements over clothing, although shoes and outer clothing were dispensed with. Some allowance is made for the increase of measurements due to clothing so that weights, for example, are reduced to nude values. Hrdlička regrets that these are so difficult to compare with extensive series of measurements which have been made, for example, by life insurance companies, because of the varied amount of clothing in which people are measured, amounting in some cases to 8 per cent. of the total weight. Apparently the chest measurements are generally made by Hrdlička over the clothing; but girths are less used by him than breadth and depth, which are less modified by the ever troublesome clothing factor. The presence of clothes results in the measurements not being exactly comparable with those taken on young men at demobilization, the methods of taking which Dr. Hrdlička again criticizes, yet those measurements must remain for a long time the best collection of measurements of young males which has been made in this country, if not in the world, because of the fact that many of the dimensions taken were such as could be satisfactorily secured only from unclothed persons.

The book is illustrated by a large number of satisfactorily reproduced full-page plates of typical old Americans. The numerous frequency polygons are also drawn on a large scale so as to be readily interpreted. It is regrettable, however, that the marginal numbers, indicating the different classes, were drawn with a fine pen and sometimes much reduced in reproduction so that in some cases they are not very legible. In his table the author gives the number of individuals which were used in each class. He relies a great deal upon the average, but fails to give standard deviations or probable errors. In the absence of such standard deviations the tables of averages are less useful for comparison than they would otherwise be. The tables are inferior in this respect to those of Boas and Wissler, in which standard deviations were conscientiously worked out. A series of averages is of relatively little significance for comparison unless we have some idea of the relation between differences and probable errors.

The publishers have prepared an attractive book, both in paper, binding and printing. The whole work constitutes an important addition to the series of anthropological works which are appearing from American authors in ever increasing numbers. It is to be hoped that the interesting mixture of races which is occurring on the American continent will be made the object of further studies in the future and all such will find it necessary to refer to the data in the "Old Americans" as a basis for comparison.

CHAS. B. DAVENPORT

The Physics of the Developed Photographic Image: Monograph No. 5 on the Theory of Photography from the Research Laboratory of the Eastman Kodak Company. By F. E. ROSS. Pp. 217. D. Van Nostrand Co., 1924.

EITHER a human eye or a photographic surface forms the receiving end of nearly every optical instrument. Each responds in characteristic fashion to the intensity and quality of the light operative. Each possesses its own limitations in sharpness and fineness of detail that may be rendered. Dr. Ross's monograph deals largely with these limitations in the case of the photographic negative. Ultimate causes are considered, carefully planned and very laborious investigations are described and the results analyzed and formulated.

Grain size, form and distribution are carefully considered in two chapters, together with the factors affecting them. The scattered and somewhat conflicting data of the reciprocity law are digested and a modified law formulated. Data and theory bearing on sharpness and resolving power, largely the work of the Eastman Laboratory, are most excellent. The chapter on astronomical photographic photometry will go far toward clearing up the confusion previously existing in that field. The two final chapters on the mutual action of adjacent images and on accuracy of photographic registration of position are models of exposition of exhaustive research by a master hand. An excellent bibliography and index are added.

This monograph is the first of its kind in this field. Along with the solid meat of fact and formulation some readers will wish there had been incorporated more general discussion for the sake of orientation and more speculation as to the ultimate causes as a stimulus to the imagination. The material presented is of the class that will appeal to the technical photographer and investigator rather than to the mere taker

of pictures. To the astronomer, the photographic surveyor and to those engaged in photographic research it will be invaluable.

P. G. NUTTING

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A DILATOMETER FOR MEASURING THE HYDRATION OF COLLOIDS

THE hydration of colloids is an important phenomenon in many physiological processes, as well as in many non-living colloidal reactions. Thus it is of interest to be able to measure the rate and amount of hydration and possibly, in some instances, to estimate the forces involved in the process. The swelling of the colloidal material usually occurs to a measurable extent as a result of hydration. The increase in size has long been used as a measure of the extent of hydration. Other methods which have been used with more or less accuracy are by (1) direct measurement of the pressure necessary to prevent swelling; (2) measurement of the heat of hydration; (3) measuring the rate of increase in weight of the material during hydration; (4) determining the increase of the specific gravity of the material; (5) determining the change in the freezing point of a solution of known concentration in which the material is immersed, and (6) determining the change of the specific gravity of a known solution of alcohol or salt in water in which the material is immersed. All these methods, however, are limited in their application or subject to large experimental errors, which can not be measured. Some colloidal substances do not swell equally in all dimensions, thus, any linear measurement is not an accurate measure of the extent of hydration. It is also known that the rate of hydration varies inversely to the degree of saturation, thus the total amount of hydration largely depends upon the degree of dryness of the colloidal material. An apparent increase in volume may also be brought about by an increase in dispersion, disintegration of the colloidal aggregates, which is often accompanied by a decrease in degree of hydration[1] as, for example, when a gelatin hydrogel changes to a hydrosol, or solid starch grains form a hydrosol when heated. A portion of the water held by a colloidal substance may be held by surface tension and thus not be water of hydration.

Hydration is regarded as a physical, chemical or physico-chemical union of water with many colloidal and non-colloidal substances. In any case, there is either a physical or a chemical condensation of the water; as in cases where there appears to be a purely physical relation the water is held in a highly compressed condition on the surface of the colloidal particle by the force of attraction between the two substances, or hydration is a phenomenon of solid solution; or there may be evidence of a chemical change, the water being held in a weak chemical union by the molecules of the substance.[2] If the colloid is a protein, some believe that the ions of the protein molecules are the units which are hydrated.[3] Thus a condensation or decrease in the volume of the water during the process of hydration furnishes an accurate measure of the rate and extent of the hydration. The volume of condensation of water at saturation in cubic millimeters per gram of dry material is here termed the "hydration factor" which is characteristic of the material under the conditions of the determination.

Some fraction of the water absorbed is held in a non-condensed condition and is not to be considered as a part of the water of hydration. This fraction varies with the conditions and the kind of material used. It is often impossible to measure the absolute amounts of water of hydration and water held in a non-condensed condition, but for comparative purposes the relative amounts of each are represented by the ratio of the hydration factor to the total amount of water absorbed per gram of dry material. This relation is termed the "hydration ratio." Thus the hydration ratio indicates the relation between the amount of water of hydration and the amount of the more mobile supply of water held in a non-condensed condition. It is probable that the water of hydration has the more important function in physiological processes and the water held in a non-condensed condition is utilized in hydration as these processes continue.

With some substances, as starch, for example, the absolute amount of water held in a non-condensed condition may be measured by the increase in weight of the dry material after it has attained equilibrium with air saturated with water vapor. In such cases, from the amount of water of hydration per gram of dry material and the hydration factor, the decrease in volume of a unit volume of water is easily calculated. The pressure necessary to cause an equal decrease in volume of pure water may be determined by referring to tables of the volume of water at dif-

[1] Fischer, Martin, and Coffman, W. D., *Jour. Am. Chem. Soc.*, 40: 304, 1918; Fischer, Martin, "Soaps and Proteins," New York, pp. 219, 1921.

[2] Loeb, J., "Proteins and the Theory of Colloidal Behavior," pp. 194, 1922.

[3] Jones, H. C., *Am. Chem. Jour.*, 34: 291, 1905.