professors have been advanced to the grade of associate professor: Carroll W. Doten, in economics; A. A. Blanchard, in inorganic chemistry; S. M. Gunn, in sanitary biology and public health; A. T. Robinson, in English; A. G. Woodman, in food analysis. The following instructors have been advanced to the grade of assistant professors in the departments indicated: Charles W. Green, in electrical engineering; Henry H. W. Keith, in naval architecture; John F. Norton, in chemistry of sanitation; Joseph W. Phelan, in inorganic chemistry; George W. Swett, in machine design, Frederick H. Lahee in geology. Assistants advanced to the grade of instructors are: Ralph G. Adams, in mechanical engineering; Arthur E. Bellis and Charles L. Burdick in theoretical chemistry; Edward A. Ingham in biology; Norman Osann in electrical engineering, and DeWitt M. Taylor, in mechanical engineering.

DISCUSSION AND CORRESPONDENCE

INTERPRETATIONS OF THE ANOMALIES OF GRAVITY

UNDER this title Mr. G. K. Gilbert discusses[1] the investigations of Messrs. Hayford and Bowie[2] (of the Coast and Geodetic Survey) relating to terrestrial gravity, and its application to observed earth movements by J. W. Spencer.[3] Any consideration of such important new problems should be welcomed as they tend to confirm previous results, or show their weakness or the lack of information.

Hayford and Bowie have stated that, for the purpose of making computations, the earth's crust is assumed to be in a state of perfect isostacy. They show, contrary to Gilbert's ideas on the subject, that while this is true for the whole area of the United States, there are large areas where the anomalies depart slightly from the perfect balance and smaller areas where the anomalies are considerable. This last is the special feature of Spencer's application of the anomalies of gravity to earth movements. Thus, at Washington, the excess of gravity is equal to 1,200 feet, while the deficiency at Virginia Beach (160 miles distant) is equivalent to a thickness of 1,600 feet of rock.

Hayford and Bowie have found that the topography is all compensated within a depth of 122.2 kilometers below sea-level (although they used 113.7 km. in their gravity computations); that is, the condition of stress at and below the depth of compensation is isostatic, or in other words "any element of the mass is subject to equal pressures from all directions as if it were a perfect fluid." Gilbert has misconstrued their conception of this, for he states "immobility at all depths below that of compensation is either explicitly or implicitly assumed by Hayford and Bowie." He also appears to take the view that even very small areas are completely compensated, and that much of the compensation in the vicinity of the stations, with decided or large anomalies, is located in the nucleus. This view is untenable as shown by such anomalies as those of Washington and Virginia Beach, or still greater ones between Olympia and Seattle. This compensation, located in the nucleus, presupposes very high rigidity, which is contrary to the idea of complete local isostacy, which on the other hand presupposes great plasticity.

Gilbert discusses the causes of the anomalies, favoring the one based upon the local variation of density of the column and heterogeneity of the nucleus with a sub-crustal mobile layer, which accounts for the isostacy. But all materials of the earth's crust are mobile under long-continued stress differences, yet there is sufficient rigidity in the crust to sustain local anomalies.

In his discussion, Gilbert assumes that the nucleus is composed of the same materials as

[1] U. S. Geological Survey, Professional Paper 85-*C*, pp. 29–37.

[2] Hayford, J. F., and Bowie, William, "The Effect of Topography and Isostatic Compensation upon the Intensity of Gravity," U. S. Coast and Geodetic Survey Special Pub. No. 10, Washington, 1912; Bowie, William, "Effect of Topography and Isostatic Compensation upon the Intensity of Gravity," *id.*, Special Pub. No. 12, Washington, 1912.

[3] Spencer, J. W., "Relationship between Terrestrial Gravity and Observed Earth Movements of Eastern America," *Am. Jour. Sci.*, 4th ser., Vol. 35, pp. 561–573, 1913.

those of the crust, and that the great density of the earth (5.6) is due to "compression by pressure," in spite of the remarkable incompressibility of even water, with the interior heat acting contrariwise. The most commonly accepted view of the great weight of the nucleus of the earth is that it is composed of heavy metallic substances; for instance, astronomer Ball regards meteorites as the remains of disrupted planets such as would be liberated by the explosion of the earth.

Concerning the relationship between the anomalies of gravity and earth movements, Dr. Gilbert says:

> Spencer emphasizes the fact that there are large plus anomalies within the region once covered by the Laurentian ice and regards it as proof that the rising of the region after the removal of the ice load was not caused by the removal of the load.

Again he says:

> The fact (of plus anomalies within this area) may equally be used to discredit the hypothesis underlying his mode of interpreting anomalies.

These statements give neither the facts nor arguments upon which Spencer bases his hypothesis that the anomalies are not due to the removal of an ice load, nor how the facts discredit his hypothesis. Observing that the plus anomaly (equaling 700 feet of rock) north of the Adirondacks, and the deformation (of 650 feet) of the earth's crust as seen in the tilted beaches, closely agree, Spencer naturally concluded that there is a direct relationship between the two phenomena. Farther south in the Adirondacks, composed of dense rocks, the anomaly of gravity is reduced to 200 feet of rock. Southward from this and extending over a very great region once covered by ice the anomalies show deficiency of weight. If the deformation adjacent to the St. Lawrence River were due to the removal of the ice sheet, then the region to the south should also have been elevated to isostate equilibrium.

Supporting Spencer's conclusions, from evidence lying outside of the glaciated region, the Appalachian belt and Florida are overweighted, although much material has been removed from the mountains. On the other hand, the coastal region is found to be underloaded, although it is here that the deposition of the materials, brought down from the mountains, have accumulated. This underloading agrees with the subsidence shown by the canyons and valleys indenting the submarine border of the continent. Yet this collateral evidence is not considered by Gilbert.

The observation of all these features is of comparatively recent date, yet they have the greatest value, although they are contrary to the hypothesis that the mobility of the earth's crust is so complete that areas of considerable size can not either be loaded or unloaded, without being fully accounted for in the isostatic balance. The phenomena of earth movements and of anomalies of gravity introduces new features in the evolution of our continents, which have only begun to be investigated.

It may be added that Professor Leverett and also Mr. Taylor have just announced that they have found moraines in the lake region, in disagreement with the hypothesis that the deformation of the earth's crust is due to the removal of the ice—results in accord with relationship of the anomalies of gravity and earth movements as lately first described by the present writer.

J. W. Spencer

Heads of Departments: A Commentary upon Dr. Johnston's Article

It was very wholesome reading that Doctor Johnston offered the heads of departments in his article upon University Organization, appearing in the December 26 issue of Science, p. 908. The unfortunate conditions described so truly he evidently finds existing not in any one special institution, but in many.

Any fair-minded head realizes the disadvantages under which younger members of his staff labor. Unfortunately, there are many professors who are quite content to allow their associates to remain unheard and unheeded, either because they honestly (and ignorantly) believe them lacking in wisdom or because they fear the effect of allowing them to be in the least prominent. For such, as well as for the more liberally inclined,