Charles Lawrence Sargent : Alloys of Tungsten and of Molybdenum obtained in the Electric Furnace.

Charles Hugh Shaw : A Comparative Study of the flowers of *Polygala polygama* and *P. pauciflora*, with a Discussion of Cleistogamy.

Albert Duncan Yocum : An Inquiry into the Fundamental Processes of Addition and Subtraction.

COLUMBIAN UNIVERSITY.

Eugene Byrnes : Experiments on the direct Conversion of the Energy of Carbon into Electrical Energy.

Charles Russel Ely : Investigation of Phenomenon of Deliquescence and of the Capacity of Salts to attract Water Vapor.

Ernestine Fireman : The Action of Phosponium Iodide on Tetra and Penta Chlorides.

UNIVERSITY OF CALIFORNIA.

Walter Charles Blasdale : A Chemical Study of the Indument found on the Fronds of Gymnogramme triangularis.

BRYN MAWR COLLEGE.

Florence Peebles : Experiments in Regeneration and in Grafting of Hydrozoa.

UNIVERSITY OF MICHIGAN.

Eugene Cyrus Woodruff : The Effects of Temperature on the Tuning Fork.

UNIVERSITY OF MINNESOTA.

Bruce Fink : Contributions to a Knowledge of the Lichens of Minnesota.

UNIVERSITY OF NEBRASKA.

Charles Fordyce : The Cladocera of Nebraska.

PRINCETON UNIVERSITY.

Henry Norris Russell : The General Perturbations of the Major Areis of Eros caused by the Action of Mars ; with the corresponding Terms in the Mean Longitude.

VANDERBILT UNIVERSITY.

J. Magruder Sullivan : Coal Tar Pitch and its High-boiling Fractions and Residue.

UNIVERSITY OF WISCONSIN.

Carl Edward Magnusson : The Anomalous Dispersion of Cyanin.

INERTIA AND GRAVITATION.

IT was shown by J. J. Thomson ('Effects produced by the Motion of Electrified Bodies,' *Phil. Mag.*, April, 1881), that a charged body has more inertia than an uncharged one.*

In 1890* and 1891† the writer introduced, for the first time, the conception that it was not only, as in the electrochemical theories of Davy, Berzelius, Helmholtz, and others, atoms in chemical combination or the dissociated components of a molecule, which had charges ; but that all atoms, even in such substances as metallic copper and silver, possessed charges, and that the so-called neutral atoms were not devoid of charges, 'but had equal quantities of both kinds of electricity.'

For practically a year it was found impossible to secure publication of this theory, the two principal objections which the editors to whom it was sent made to it being that in the first place it was a fundamental fact that all electric charges must reside on the outside of conductors, and that consequently the atoms of a conductor, such as copper, could not possibly have individual charges, and secondly that 'the atoms, being self-evidently conductors themselves, or else the metal as a whole could not conduct,' the postulated equal charges on the atoms would immediately neutralize each other. A brief note was finally published by the kindness of the editor of the *Electrical World* in that paper,‡ but accompanied with an editorial to the effect that though the numerical relations connecting the elastic constants with atomic volume, discovered by the writer and adduced as proof of the theory, were no doubt interesting, the theory was probably wrong, and the efforts due 'to intermolecular forces just about sufficient to account for the particular sort of strain which we know as an electric charge.'

The above is not mentioned for the purpose of discrediting the judgment of the editors referred to, for when even specialists did not, at a much later date, see that it could be reconciled with the physical facts,

* The formula there given contains a slight slip in the numerical coefficient, as was first pointed out by Heaviside. $\frac{1}{3}$ should be written for $\frac{2}{15}$.

* Lecture, Elect. Soc., Newark, May, 1890.

† *Elec. World.*, Aug. 8 and Aug. 22, 1891.

there is, of course, much excuse for those who were not specialists in this particular line. But attention is called to it as illustrating the general trend of ideas at the time when the writer first attempted to introduce his theory.

Some time later, in Europe, similar ideas were put forward by other writers, notably by Richartz, Lorentz, Chattock, Larmor and others, and at the present time the theory may be considered to be on a strong footing.

The theory thus originated by me, that the ionic charge is always associated with the atom, in all conditions, naturally led to the conception that it might be the inertia effect of such a charge, acting in the way first shown by J. J. Thomson, which caused the inertia of matter. This idea was advanced by several writers, amongst others by Dr. Kennelly. But it was easily shown, and had in fact been ascertained previously by the writer, and no doubt by others, that, with the known dimensions of the atom, this hypothesis was untenable, the effect so produced being only about 10^{-8} of that necessary.

In subsequent papers,* the writer put forward the idea that "the atoms may be formed of vortex rings arranged in different kinds of space nets, with the direction of rotation of the vortex rings such as will make these combinations stable," and that "one might picture to one's self a vast portion of the 'atom dust' from which Mr. Spencer develops his universe, made of vortices and splitting up in these 67 ways to form the elements."

This hypothesis had for some time no real foundation. During the past year, however, the wonderful work of J. J. Thomson has resulted in almost certain proof of the fact that the atom is really made up of a large number of what he calls 'corpuscles,' each possessing an electric charge. In this paper (in the December number of the *Phil. Mag.*, 1899), Thomson recurred to the question of inertia being an electrical effect, but considered that there is at present no evidence to decide whether the corpuscles are small enough.

In 1891 the writer had shown that the atoms of a body in the solid state must be nearly touching each other, and that the phenomena which were supposed to militate most strongly against this supposition could be accounted for in a very simple manner. In a later paper* (read before the A. A. A. S., Columbus meeting, August, 1899), I showed that though the atoms were nearly touching each other, yet they really filled less than $\frac{1}{4}$ per cent. of the space which they occupied to the exclusion of other atoms.

From the two facts, *i. e.*, Thomson's discovery that the number of corpuscles in a hydrogen atom is of at least the order of one thousand, and the writer's discovery that the real volume of the atom is but a small portion of the space occupied by the atom, we arrive at the conclusion that the atom must be made up of a large number of corpuscles separated from each other by distances considerably larger than their diameters. This gives us data for making an approximate estimate as to the ability of the corpuscular charges to account for the inertia of the atom, and on making this calculation, we find, as the writer has shown,† that it really is the probable cause.

In other words, we may feel fairly confident that inertia is really not a separate and distinct thing, but merely a property due to the fact that the atom is made up of a very large number of electric charges.

I have recently found that gravitation can also be accounted for as a property

* Articles on Insulation, *Elect. World*, March, 1893, *et seq.*

* 'A Determination of the Nature of the Electric and Magnetic Quantities and of the Density and Elasticity of the Ether,' *Phys. Rev.*, January, 1900.

† 'Inertia.' *Elect. World*, 1900.

of these same corpuscular charges. It was first pointed out by Newton that if the density of the ether continually increased as we move away from a particle of matter, that we should obtain a gravitational effect. Later it was shown by other writers, notably by Kelvin, that the same result would follow if the density decreased. No way of accounting for this continuous variation of density has as yet been suggested. Again, it was shown by Maxwell that on any stressed medium theory of gravitation, the stresses must be enormous, whilst the estimates given by Kelvin of the elastic constants for the ether were not such apparently as to permit of this. But the writer showed, in the paper above referred to, that the elasticity of the ether is immensely great, *i. e.*, 6×10^{20}. Now if we calculate, as I have done in one of the papers referred to, what the diameter of the corpuscle must be, in order that it shall give the inertia effect, and from that calculate the electrostatic stress at the surface of a corpuscle, we find that it is of the order 10^{20}, and this stress acting on a medium whose elastic coefficients are as given, I have found, can produce a change of density sufficient to give the observed gravitational attraction.

We thus find that both inertia and gravitation are electrical effects and due to the fact that the atom consists of corpuscular charges. The constant ratio between quantity of inertia and quantity of gravitation, for a given body, is thus explained. We may state the theory thus :

The inertia of matter is due to the electromagnetic inductance of the corpuscular charges, and gravitation is due to the change of density of the ether surrounding the corpuscles, this change of density being a secondary effect arising from the electrostatic stresses of the corpuscular charges.

A fuller paper on this subject is in course of preparation, but will be delayed for some time by pressure of other work.

I may here mention that I have found that the equation

$$M/L^3 = M/LT^2 \times T^2/L^2,$$

given in the paper in the *Physical Review*, above referred to, and stated to represent a phenomenon not yet discovered, really represents Kerr's electrostatic optical effect, and the above gravitational effect, and that this effect therefore varies directly with the elastic coefficient of the dielectric. As this is one of the remaining links necessary to complete the full chain of proof of the theory there given, this latter is thus put upon a still firmer footing.*

The weight of matter in a gaseous state should be very slightly greater than in the solid state, and iron should weigh slightly less when dissolved. It is doubtful, however, whether the experimental conditions are not too difficult. If the measurement could be made it would give an independent method of arriving at the size of the corpuscle.

The writer has pointed out that the Kelvin-Maxwell theorem, deduced from the phenomenon of the electromagnetic rotation of light, that whenever we have a magnetic field we have also a rotation of the medium, is incorrect, in that it assumes that light consists of a certain kind of periodic motion for which there is no evidence. The question arises : In spite of the fact that the supposedly general theorem is incorrect, is there any actual material rotation concerned in the electromagnetic rotation of light? The answer I would give is 'yes, but not as a cause, merely as an effect.' According to the theory advanced by the writer,† the rotation is a consequence of light absorption, and can only take place in an absorbing medium. When the light waves strike the atoms, if the period of vi-

* A Determination of the Nature of the Electric and Magnetic Quantities. *Phys. Rev.*, January, 1900.

† *Ibid.*

bration of the corpuscular groups is very different from that of the waves, there is no absorption, and the light passes through unchanged. But at or near synchronism the group is set in vibration and causes the electric displacement to lag behind the voltivity. Hence, the group being set in vibration, and being in a magnetic field, it must, as was first pointed out by the writer,* and later by Lorentz, rotate. But this rotation is not a *cause* of the light rotation, but an effect.

Reginald A. Fessenden.

THE WORK OF THE SOCIETY FOR AGRICULTURAL EDUCATION.†

During the sixties in the Agricultural College, with which I have long been connected, one professor taught classes in agriculture, animal physiology, veterinary, breeds of live stock, stock feeding, farm crops, civil engineering, and was superintendent of the farm. In recent times this work has been placed in the hands of a dozen or more persons. I need not enumerate similar instances of the recent division of labor as exemplified in our universities. This is a day of specialists and the end is not yet.

The American Association for the Advancement of Science, which we shall attend here next week, when first organized had no sections, but the members all met together as long as the meetings continued. By degrees, as you all know, they increased till there are now nine sections, each with a full quota of officers, not to mention some sub-sections.

Recently, as though this was not enough, there have been formed a considerable number of distinct organizations, the programs of some of which contain much the same range of papers, presented mostly by the same members as those in the parent society.

Meetings during this week and next will be held here by fifteen affiliated societies.

In December, 1898, nine separate societies met during the same week at this university, and nearly every paper presented would have been received by some of the sections of the American Association.

The Fifth Congress of American Physicians and Surgeons was held at Washington, D. C., on May 1st, 2d and 3d. Fourteen distinct societies joined in the triennial Congress.

In much the same way journals occupying special fields of science have multiplied.

Previous to 1880, a number of American societies were organized for the discussion of agricultural topics and those of a kindred nature. For several reasons most of these survived only long enough to hold from one to three meetings.

In 1880, at Boston, a new plan was tried, viz, that of organizing the Society for the Promotion of Agricultural Science, consisting of twenty-one persons. It was the determination of its members to strive for papers of genuine worth and make no effort to draw crowded houses or to make a great display in any manner, whatever. The Society after continuing for twenty-one years has demonstrated beyond question that it is entitled to live and has important work to perform. In all, up to this time, there have been only one hundred and ten members. Those who have continued active, have been too conservative to suit a very few who were impatient for large numbers and more display. To most of us, it seemed of first importance to become acquainted with each other and learn the peculiarities of the members. Some men are restive and never remain active in any society for a very long time. Such may be expected to drop out and others will be elected to fill the places left vacant. Had

* *Elect. World,* May 18, 1895.

† President's Address at the Twentieth Meeting of the Society for the Promotion of Agricultural Science.