be restricted to a condition in which the components of a molecule are in no way connected by chemical bonds; the possibility of the independent diffusion of the molecular components through porous membranes would afford a simple test as to whether molecules were really dissociated or not. The term dissociation as applied to electrolytes, in which this independence of the ions does not exist, is obviously a misnomer. There is said to be an electrical force acting between the various oppositely charged ions into which a dissolved molecule separates, which in some way still binds them. Even in dilute solutions this force is very considerable, and must make the condition of charged ions moving independently in the liquid so unstable as to be dynamically impossible unless other important forces operate at the same time. Although the present theory of free ions affords a rough working analogy, yet it is illusory and misleading, and threatens to prevent important advances by its illusive appearance of explanation. It must not be forgotten that the older theories of light and the caloric theory of heat constituted stumbling-blocks long after their inadequacy had been conclusively demonstrated.

Prof. Fitzgerald thus contends that the fundamental conceptions underlying many of the current physico-chemical theories, such as those of osmotic pressure and electrolytic dissociation, are dynamically unsound, so that all attempts to gain an insight of what occurs in solution by their aid are necessarily unsuccessful. He seems to consider that an unyielding adhesion to these theories has led to an illogical habit of thought upon such matters, and has made possible the inaccurate application of thermo-dynamical reasoning. W. J. P.

NEW EXPERIMENTS ON THE KATHODE RAYS.[1]

(1) TWO hypotheses have been propounded to explain the properties of the kathode rays.

Some physicists think with Goldstein, Hertz, and Lenard, that this phenomenon is like light, due to vibrations of the ether,[2] or even that it is light of short wavelength. It is easily understood that such rays may have a rectilinear path, excite phosphorescence, and affect photographic plates.

Others think, with Crookes and J. J. Thomson, that these rays are formed by matter which is negatively charged and moving with great velocity, and on this hypothesis their mechanical properties, as well as the manner in which they become curved in a magnetic field, are readily explicable.

This latter hypothesis has suggested to me some experiments which I will now briefly describe, without for the moment pausing to inquire whether the hypothesis suffices to explain all the facts at present known, and whether it is the only hypothesis that can do so. Its adherents suppose that the kathode rays are negatively charged; so far as I know, this electrification has not been established, and I first attempted to determine whether it exists or not.

(2) For that purpose I had recourse to the laws of induction, by means of which it is possible to detect the introduction of electric charges into the interior of a closed electric conductor, and to measure them. I therefore caused the kathode rays to pass into a Faraday's cylinder. For this purpose I employed the vacuum tube represented in Fig. 1. A B C D is a tube with an opening a in the centre of the face B C. It is this tube which plays the part of a Faraday's cylinder. A metal thread soldered at S to the wall of the tube connects this cylinder with an electroscope.

E F G H is a second cylinder in permanent communication with the earth, and pierced by two small openings at β and γ; it protects the Faraday's cylinder from all external influence. Finally, at a distance of about 0·10 m. in front of F G, was placed an electrode N. The electrode N served as kathode; the anode was formed by the protecting cylinder E F G H; thus a pencil of kathode rays passed into the Faraday's cylinder. This cylinder invariably became charged with negative electricity.

The vacuum tube could be placed between the poles of an electro-magnet. When this was excited, the kathode rays, becoming deflected, no longer passed into the Faraday's cylinder, and this cylinder was then not charged; it, however, became charged immediately the electro-magnet ceased to be excited.

In short, the Faraday's cylinder became negatively charged when the kathode rays entered it, and only when they entered it; *the kathode rays are then charged with negative electricity.*

The quantity of electricity which these rays carry can be measured. I have not finished this investigation, but I shall give an idea of the order of magnitude of the charges obtained when I say that for one of my tubes, at a pressure of 20 microns of mercury, and for a single interruption of the primary of the coil, the Faraday's cylinder received a charge of electricity sufficient to raise a capacity of 600 C.G.S. units to 300 volts.

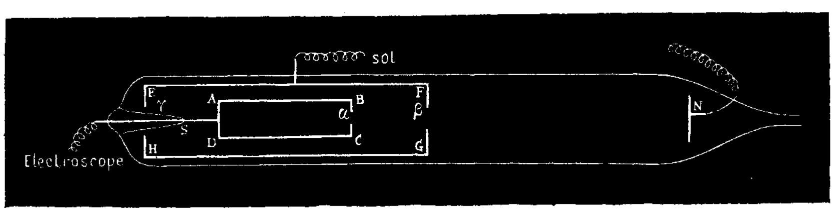

FIG. 1.

(3) The kathode rays being negatively charged, the principle of the conservation of electricity drives us to seek somewhere the corresponding positive charges. I believe that I have found them in the very region where the kathode rays are formed, and that I have established the fact that they travel in the opposite direction, and fall upon the kathode. In order to verify this hypothesis, it is sufficient to use a hollow kathode pierced with a small opening by which a portion of the attracted positive electricity might enter. This electricity could then act upon a Faraday's cylinder inside the kathode.

The protecting cylinder E F G H with its opening β fulfilled these conditions, and this time I therefore employed it as the kathode, the electrode N being the anode. The Faraday's cylinder is then invariably charged with *positive electricity*. The positive charges

[1] Translation of a paper by M. Jean Perrin, read before the Paris Academy of Sciences on December 30, 1895.

[2] These vibrations might be something different from light; recently M. Jaumann, whose hypotheses have since been criticised by M. H. Poincaré, supposed them to be longitudinal.

were of the order of magnitude of the negative charges previously obtained.

Thus, at the same time as negative electricity is *radiated* from the kathode, positive electricity travels towards that kathode.

I endeavoured to determine whether this positive flux formed a second system of rays absolutely symmetrical to the first.

(4) For that purpose I constructed a tube (Fig. 2) similar to the preceding, except that between the Faraday's cylinder and the opening β was placed a metal diaphragm pierced with an opening β', so that the positive electricity which entered by β could only affect the Faraday's cylinder if it also traversed the diaphragm β'. Then I repeated the preceding experiments.

When N was the kathode, the rays emitted from the kathode passed through the two openings β and β' without difficulty, and caused a strong divergence of the leaves of the electroscope. But when the protecting cylinder was the kathode, the positive flux, which, according to the preceding experiment, entered at β, did not succeed in separating the gold leaves except at very low pressures. When an electrometer was substituted for the electroscope, it was found that the action of the positive flux was real but very feeble, and increased as the pressure decreased. In a series of experiments at a pressure of 20 microns, it raised a capacity of 2000 C.G.S. units to 10

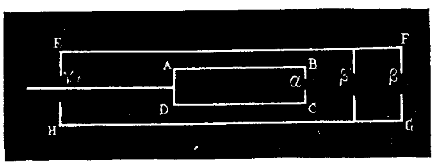

FIG. 2.

volts; and at a pressure of 3 microns, during the same time, it raised the potential to 60 volts.[1]

By means of a magnet this action could be entirely suppressed.

(5) These results as a whole do not appear capable of being easily reconciled with the theory which regards the kathode rays as an ultra-violet light. On the other hand, they agree well with the theory which regards them as a material radiation, and which, as it appears to me, might be thus enunciated.

In the neighbourhood of the kathode, the electric field is sufficiently intense to break into pieces (*into ions*) certain of the molecules of the residual gas. The negative ions move towards the region where the potential is increasing, acquire a considerable speed, and form the kathode rays; their electric charge, and consequently their mass (at the rate of one valence-gramme for 100,000 Coulombs) is easily measurable. The positive ions move in the opposite direction; they form a diffused brush, sensitive to the magnet, and not a radiation in the correct sense of the word.[2]

THE FRENCH MAGNETIC SURVEY OF THE WORLD.

IN Europe, as well as in the United States of America, the study of terrestrial magnetism has for some time played an important part.

M. le Commandant de Bernardières has written a most interesting account of the construction of new magnetic maps of the globe, undertaken by the Bureau des Longitudes. The following are a few facts given by him, which show to what extent it is contemplated to carry out the work.

From the magnetic determinations already obtained, some maps have been made; observatories too, permanent and otherwise, have been built. But the work is not entirely satisfactory. The maps are chiefly the result of observations made by navigators, and are only of limited parts scattered over the face of the earth.

In order to have a *general* magnetic map, numerous observations would have to be made, distributed over all regions, taken as nearly as possible at the same time, and in the same way with similar instruments. To this end the Bureau des Longitudes have appealed to Vice-Admiral Besnard, Minister of Marine, who has promised help, and put at their disposal officers and sailors, and also a great number of instruments. The Colonial Minister has also shown interest in the matter, and promised his assistance in the colonies.

Seven sets of observers have been organised, consisting each of a lieutenant, ensign or hydrographer, and one assistant. These expeditions have been arranged as follows:—

Atlantic Ocean	West Coast of Africa, East Coast of America, Antilles, &c.	M. Schwérer, lieutenant of the ship.
Pacific Ocean	West Coast of America	M. Blot, ensign of the ship.
Pacific Ocean	Oceana	M. Monaque, ensign of the ship.
Indian Ocean	Red Sea, South Coast of Asia, Oriental Coasts of Africa, Madagascar, and other islands	M. Paqué, ensign of the ship.
Chinese and Japanese Seas	Coasts of Indo-China, of China and Japan	M. Terrier, ensign of the ship.
—	Madeira, Canary Islands Azores, Cape Verd Islands, Senegambia	M. de Vanssay, hydrographic engineer.
Iceland	North Sea, Scandinavia, Denmark, Scotland	M. Houette, captain of the frigate, commanding the Iceland station; M. Morache, lieutenant of the ship.

With expeditions in these various parts of the earth, it will be possible to make observations almost simultaneously.

In order to determine the correct value of the magnetic elements, as well as to ascertain the exact variation of these elements, the missions have been supplied with the finest instruments, which have been adjusted at the observatories of Montsouris and Parc Saint-Maur; comparisons will also be made at every magnetic observatory at which they arrive during the expedition. Special instructions have been given with regard to calculations and method of observation, in order to insure a perfect comparison of results.

Six of these expeditions have started, and have communicated already the result of some of their first observations; the work, however, will have to be continued about two more years.

The ship *Manche*, which left France last spring, for Iceland, has returned with a great number of observations, obtained in Cherbourg, Scotland, the Shetland Isles, Iceland, Norway, and Denmark. In the observatory constructed by the *Manche* at Keykiawik, two complete observations of variations were obtained, having each a duration of eight days.

It will be very interesting to compare the results of the present day with those of the *Recherche*, obtained sixty years ago, and since then of several other expeditions. The successful return of the *Manche* certainly indicates that great things may be expected of the other expeditions, and makes it certain that a most important step has been taken by the French Government for the advancement of science.

[1] The breaking of the tube has temporarily prevented me from studying the phenomenon at lower pressures.

[2] This work has been carried out in the laboratory of the Normal School, and in that of M. Pellat at the Sorbonne.