MacCullagh's Theory of the Æther.

MR. BASSET'S criticisms in his letters in NATURE of October 17 (p. 595) and October 24 (p. 618) call for some reply. I willingly avail myself of the opportunity to attempt to make my meaning clearer.

(1) As regards the first letter, there seems to be some misconception. I have nowhere in the papers referred to given a proof, such as he supposes, of the theorem which he calls in question, viz. that a gyrostatic æther may be constructed which will function according to MacCullagh's optical scheme. That proposition is, I take it, Lord Kelvin's; and I simply gave references to his treatment, which occurs, at any rate implicity, near the end of the third volume of his "Collected Papers" (pp. 442, 466).

The principal aim of the second of the papers referred to (*Phil. Trans.* A, 1894) was, assuming the existence of a continuous medium with kinetic and elastic energies given by MacCullagh's expressions, to examine how far such a medium would fulfil the functions that are required of the æther, as (i.) the transmitter of radiation, (ii.) the medium in which electric actions consist and are transmitted, (iii.) the underlying medium in which ordinary matter may itself consist, in the form of permanent configurations of strain or motion possessing mobile characteristics. In MacCullagh's own time it was recognised, by none more than by himself, that a medium like his was in no way analogous to ordinary elastic matter. Moreover it was held by many that it was an impossible constitution for any medium at all. This latter conclusion I combatted by quoting the fact that Lord Kelvin has actually shown how to make a model, representing MacCullagh's medium, by means of a cellular structure composed of portions of ordinary matter in spinning motion. This is the only way that I intended to introduce the gyrostatic æther into the argument. For I hold it to be more rational to take matter to be a structure of molecular type in the primordial medium (which is not itself matter, but is a *continuum* with simpler fundamental properties than elastic solid matter) than it would be to take the æther to be a molecular or cellular structure built up out of ordinary matter.

The functions required of the æther show that it must be a medium which can have kinetic energy involving inertia, and also elastic energy of some kind when strained. According to MacCullagh's scheme, its elasticity would consist simply in resistance to absolute rotation; so that an element of volume of the medium is taken to have relations to directions in space, of the same general type as the axis of a spinning gyrostat actually possesses. The analysis of the interaction of this inertia and this elasticity forms a dynamical theory of the medium, but the dynamics is not the dynamics of ordinary matter.

Mr. Basset easily arrives at inconsistencies by applying MacCullagh's energy formula directly to the structural gyrostatic medium of Lord Kelvin. The reason is that the problem is one involving ignored coordinates (in the phraseology of Thomson and Tait's "Natural Philosophy") corresponding to the latent spinning motions of the imbedded gyrostats. Before the principle of least action can be applied after the manner of an ordinary continuous elastic medium, the actual energy function of the gyrostatic medium must be modified in the well-known manner, and it will thus assume a form equivalent to MacCullagh's. It would, no doubt, be interesting and instructive, as regards dynamical principles, to establish this in detail; but this is hardly the place to enter into a technical problem.

(2) As regards Mr. Basset's second letter, on the reflection of light from the surface of a magnet, the parallel which he draws between one type of theory which I provisionally uphold, and another which I reject, is, I think, not a real one. The latter theory retains the dynamical equations and surface conditions which belong to the luminiferous medium under ordinary circumstances, merely adding on to the electric force a new part of magneto-optic origin. This would hardly be open to objection if it worked; but it is admitted that it does not work, and in default of a specific reason being assigned for the discrepancy the theory fails. It is as if a machine, whose mode of working is thoroughly known under certain simple conditions, were observed to be working steadily under more complicated circumstances, while a mathematical analysis showed that it ought to get jammed under these new conditions. The inference would, I think, be that the machine has been reset, or some change made in its constitution, which obviated the jamming. Now the ordinary equations of the electric theory of light are, presumably, deducible from the energy function of the medium by the principle of least action. When the substance that transmits the light is in an extraneous magnetic field, there is a subsidiary term in the energy function which arises from this field; therefore the application of the principle of least action will now give different equations of the medium, and different boundary conditions, from those which ordinarily hold good. The statement that the boundary conditions which held for non-magnetic circumstances are not now maintained, is not to the point; the question is rather, whether the boundary conditions which are appropriate to the actual formulation of the problem can all be maintained, and if they can the theory is consistent.

J. LARMOR.

St. John's College, Cambridge, October 25.

Lightning.—Chain Formation.

ON September 9, 1895, I was cycling near Pitlochry, N.B. The day had been extremely hot—80° F. in the shade—and as dusk came on it grew somewhat foggy, and flashes of distant lightning became frequent. At ten o'clock there suddenly came on a terrific thunder-storm. Crash succeeded crash, and the lightning, of all colours, blazed almost continuously. Objects fifteen miles off could be seen as plainly, if not more so, than in bright daylight. The rain soon turned the road into a torrent, and my electric lamp failed to act properly. But the chief peculiarity was the occurrence of eight strange flashes of a chain formation, with large elliptical links, and of a golden-yellow colour. These flashes were not rapid in their passage, as ordinary lightning is wont to be; but one of them took slightly over a minute to pour from the clouds to the edge of the valley opposite me. Two of these chains of living, burning gold passed between adjacent clouds, while the remaining six came to earth, one in the field just beside me. I then went off to seek for shelter; but the storm continued till 1 a.m.

WILLIAM CRAWFORD.

Personal Injury from a Fire-ball.

IN compliance with a wish expressed by several scientific friends, I place on record an instance of damage done by a fire-ball or globular lightning. About five weeks ago, when I was in Londonderry, the circumstances were related to me by Mr. James Harvey, of Northland Road in that city. Mr. Harvey was staying during the month of August at Culdaff, on the north coast of Donegal; and on the 24th of that month, at about 4 p.m., a little boy named Robert Alcorn, whose parents occupied a house near Mr. Harvey's, was desired by his father to go into the yard and drive away some fowls from the door. On going out of the house, the boy saw a large bright object in the sky about the size of the table in his bedroom (I give his own account, leaving out necessary considerations of distances, &c.), or apparently about six square feet in area. The object came towards his house from the west, or north-west; and when it came close, it partly burst with a report like that of a gun. He put his hands over his face to shield himself from "the spark," and after the explosion the bulk of the ball appeared to continue its course towards the east, low down. When it burst, however, it struck him, shattering the thumb and the first and second fingers of the left hand, cutting, scratching, and blackening the right hand and left cheek, and shattering into fragments several bone buttons on his coat. Very soon afterwards, Dr. R. Young, of Culdaff, and Dr. Newell, of Moville, attended the boy, and amputated the fingers and a portion of the thumb.

No one near the place *saw* the ball (except the boy, of course), but the parents and several others heard the report, and the boy's father rushed out immediately and caught his son as he was falling. Mr. Harvey soon afterwards examined the place, and could find no further trace of the fire-ball, except that a piece of bark had been knocked off a small tree within a few feet of the place where the boy was struck. The local police made exhaustive inquiry as regards the possibility of any one's having fired a gun at the boy, or of his having had any explosive in his possession; but nothing of the kind transpired.

It is well to add that at Redcastle (about eight miles away), one of the residents saw, on the same day, a bright object in the sky, which object he took to be a fire-ball. The day was stormy, with heavy showers, but no thunder.

M. Jamin relates ("Cours de Physique," tome premier, p. 470) several instances of globular lightning, and from these I select