

all-pervading æther shall be at rest under normal conditions; the effect of any local disturbance due to matter must thus be a local effect, and the distant regions of æther will remain unmoved. There can be no question of ascribing a uniform motion to the whole of the æther, extending to the remotest infinity, because there is no conceivable means of producing or altering such a motion. In other words, an infinitely extended æther postulates absolute motion as a fact, in the only real sense of that term, namely, motion relative to the remote quiescent regions of the æther; and once that determination is made, arguments from relativity of motion must lapse.

The interesting point raised by Prof. Richardson, that the steady field of a uniformly moving electron would contain an infinite amount of moment of momentum, requires detailed consideration; but it is not without parallel in more familiar departments of abstract physics. Its scope may be illustrated by the steady motion of a solid sphere in infinitely extended viscous fluid. The sphere, even when in steady motion, experiences resistance, and must be pushed along in order to maintain its motion. This steady push must impart momentum to the fluid, which increases in amount without limit as the time is prolonged; and it is, in fact, well known that the field of flow around the sphere when it has reached its ultimate theoretical steady state contains an infinite amount of linear momentum. But this circumstance does not vitiate the dynamics of fluid resistance. For, in fact, the steady state of motion is very soon set up throughout the neighbourhood of the moving sphere, while the continued supply of momentum simply diffuses away into the distant regions where the velocity is so slight that it does not react sensibly upon the resistance to the sphere. Similar considerations apply to the case of an electron set into steady translatory motion through æther. Here it is rotational momentum that is steadily imparted to the surrounding æther as time goes on, and is carried away into the distant regions by wave-motion. This requires that the æther exerts a torque on the moving electron, the reaction of which on the æther is the source of the angular momentum communicated to that medium. The possibility of permanent adjustment to a torque of this kind is not here anomalous; it is provided for in the fundamental hypothesis of elastic resistance to absolute rotation of the parts of the æther. There is, however, a fundamental difference from the previous illustration of a solid sphere moving through infinite viscous fluid. In that case the force continually does work, leading to continued dissipation of energy into the viscous fluid. But in the electric case the energy in the æther settles down to a steady value, and no further energy is put into it, although a constant stream of angular momentum is put into it so long as the motion of the electron goes on.

The validity of illustrating the nature of magnetic force by velocity of the æther rests on an application of the Principle of Least Action. The power of that principle resides in its allowing dynamical inferences to be drawn without requiring detailed scrutiny of the mechanism through which the forces operate. But the exceptional character of the hypothesis of rotational elasticity, or the possibility of some flaw in the argument, might conceivably have put the application of the principle at fault. It is thus essential, both for verification and for clearness of view, to scrutinise in detail the circumstances of the motion as determined by the Principle of Action, so far as possible. It would appear that, as regards the interesting feature discussed by Dr. Richardson, nothing has gone amiss.

Even in the case of a sphere set in motion in frictionless fluid, it may be said in the same way that when the steady motion has become absolutely established by propagation outward, an infinite amount of momentum has been transferred from front and rear to the sides.

Cambridge, July 8.

J. LARMOR.

IN NATURE of July 4, Mr. E. Cunningham discusses my statement of an objection to identifying the magnetic vector with translational velocity of the æther. Mr. Cunningham says:—"If it were definitely stated that the magnetic force in the free æther was proportional to the velocity of the

æther relative to the observer the objection would be valid"; and certainly any theory which embodied such a doctrine would stand self-condemned. My argument, however, was not directed against this obviously untenable view.

If, for the free æther, we assume that magnetic force is, within a constant factor, identical with æthereal velocity, then we can determine the velocity of the æther at any point by measuring the magnetic force at that point. For the value of the magnetic force there is a perfectly definite physical criterion, which is independent of any arbitrarily chosen frame of reference, and hence we should have the means of determining *absolutely* the velocity of the æther. Thus, on our assumption, absolute motion attains to a definite physical significance which has no counterpart in the postulates of ordinary dynamics; and, this being so, dynamics must fail to give a true account of electromagnetism.

Accordingly, when we identify the magnetic vector with translational æthereal velocity, and at the same time assume that we are dealing with a dynamical system, we should expect to be led to results inconsistent with known electromagnetic relations. Consider, in fact, the unaccelerated motion of a charged body (or of an electron) through a space where there is no magnetic intensity. Then pass to the case where the space in question is uniformly pervaded by magnetic force in a direction transverse to the motion of the charged body, while at the same time a new component is added to the motion of the body, identical in direction and magnitude with the æther-drift which we assume to constitute our magnetic field. We have thus impressed a uniform velocity on the whole system considered, and if the system is fundamentally a dynamical one, no new acceleration will thus have been introduced: that is, the charged body will move without acceleration across the lines of magnetic force.

C. V. BURTON.

Cambridge, July 12.

Root Action and Bacteria.

IN NATURE of June 6 (p. 126), Mr. S. Pickering has a note on "Root Action and Bacteria" in which he concludes that the proper functioning of roots depends on the presence of bacteria.

Experiments I have made here both in the field and in water culture with a large number of varieties of plants do not lead directly to the same conclusion. Water cultures have been made on a fairly large scale, three harvests of ninety plants being taken in a large number of dishes, each containing two litres of water. After the third harvest, the water was allowed to stand and evaporate to half its volume. On attempting to use this water for further water cultures, all the plants sown in it died within two days and some within half an hour, the time varying with the variety of plant that was transplanted into the water, and with the variety that had previously been grown in the water.

Further, boiling this water neither increases nor diminishes its toxicity to plants. It is, moreover, immaterial whether the nutrient solution is such as to become acid or alkaline after use; neutralisation in either case does not make it possible to grow plants in it.

My experiments lead to the conclusion that the roots of all the plants so far tried excrete a substance that is toxic to all plants (including that by which it is excreted), but in different degrees.

Similarly, in the field *Sesunum indicum* will not grow (on stiff black soil) within 2 feet of *Sorghum vulgare*; all the plants tried appear to decrease the yield of neighbouring plants of the same variety by about 50 per cent.

The effect of the toxic substance both in the field and in water culture is completely neutralised by tannic and pyrogallol acids, carbon black, and other substances.

It is, of course, possible that bacteria in the soil have a beneficial action by elaborating antitoxins similar to those mentioned.

I have not yet been able to isolate the toxic substance contained in the polluted water of my cultures.

F. FLETCHER.

Poona, June 21.