(*c*) H. A. Lorentz's modification of Maxwell's theory, which when combined with the Lorentz transformation is universally accepted to-day, involves an immobile æther which is therefore incapable, by itself, of possessing kinetic energy. The theory retains, however, Maxwell's original assumption that an electric current *per se* has no inertia, an assumption since proved by experiment to be incorrect.

(*d*) One may then legitimately ask, of those who reject my hypothesis: "What *is* magnetic energy ?".

(*e*) Since an electron can be transformed, by collision with a positron, into electromagnetic radiation, it is reasonable to take its mass as being entirely electromagnetic, although as yet the only microscopic explanation of this is the unsatisfactory one in which classical theory is applied to the external field of a billiard-ball model.

(*f*) In modern theories of conduction the electron is treated in an over-simplified way. It is electrically charged, it is true, but its magnetic properties are largely ignored (an exception is L. Brillouin, *Helv. Phys. Acta*, **7** (Supp.), 47 (1934)). Its kinetic energy is somehow regarded as 'mechanical'. The logical deduction from this is that, when free electrons are accelerated in a vacuum to high energies, their kinetic energy eV is mechanical not magnetic, so that, contrary to all accepted theory, moving charges do not cause a magnetic field.

(*g*) If two electrons, macroscopically coincident, are moving in opposite directions with equal velocities, they cause no resultant macroscopic magnetic field. In a conductor carrying no current it is accepted, in modern theories, that the conduction electrons have random velocities with a Fermi-level of the order of 10^6 metres per sec. When an electric field is applied, almost all the conduction electrons continue to have paired velocities so that their macroscopic magnetic field is nil, but an extremely small proportion attain energies which are not balanced by electrons moving in the opposite direction. The macroscopic magnetic field must therefore be due to this very small proportion of electrons, moving with high velocities.

(*h*) The mechanism, possibly quantized, whereby an applied electric field imparts energy to the conduction electrons is unknown, and the hypothesis, based on a free electron gas, that every conduction electron has its energy changed by a small amount according to classical mechanics may well be entirely wrong. I have shown that if the magnetic field is due to a very small proportion of the available conduction electrons, moving with high velocities, their kinetic energy, even if m is taken to be equal to m_0, is of the same order of magnitude as the magnetic energy in typical current circuits.

(*i*) In my hypothesis the mass of a conduction electron is not to be considered as being limited to the 'particle'. It is the electron's share of the mass of the total electromagnetic energy, both internal and external, of all the current-carrying electrons in the circuit, and must be regarded as extending throughout the electromagnetic field. It thus satisfies Maxwell's general hypothesis quoted in (*a*) above. If the current is steady, this electromagnetic energy is considered to move with the same mean velocity as the electrons. There is no universal material medium through which electromagnetic energy can move only with the speed of light; but when the current changes, then the consequent disturbance of the steady conditions is communicated to a distant element of the field with the velocity of radiation.

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[1] *Nature*, **182**, 1045 (1958).
[2] Longmans, Green and Co. (1957); second ed. (1959).
[3] London, F., *Superfluids*, **1**, 66 (Wiley, New York, 1950).
[4] (*a*) Maxwell, J. C., *A Treatise on Electricity and Magnetism*, **2**, §552 (third ed., 1892); (*b*) *ibid.*, §636.

PROF. CULLWICK has directed attention to an incorrect statement, which I regret, in my review of the first edition of his book *Electromagnetism and Relativity*. As he says, the fundamental relation derived from his hypothesis (equation (1) of his communication) differs in sign from that usually adopted in the theory of superconductors so that Prof. Cullwick's hypothesis cannot be identified with the former—contrary to my statement.

My error, however in no way invalidates my contention that Prof. Cullwick's hypothesis is misleading. In the first instance, the relation $m\mathbf{v} = e\mathbf{A}$ is itself misleading, since it implies that the mean velocity of the conduction electrons is in all cases in the direction of the local vector potential. This is certainly not true, and in the second edition of his book the author has modified this relation in an attempt to overcome its shortcomings. Secondly, and this was my main contention, the hypothesis is misleading since in no sense can the magnetic energy be identified with the kinetic energy of the effective conduction electrons. In fact, the former is field energy propagated with the speed of light, and so cannot be identified with mechanical energy of the motion of the electrons. In any event, I cannot see what useful purpose such an identification would serve. In Maxwell's dynamical theory of electric currents a useful formalism is developed along the lines of Lagrange's analytical dynamics in which the magnetic energy of the electric current is shown to be the 'analogue' of the kinetic energy in a mechanical system. There is no implication that the two forms of energy are of the same nature. (In fact, Maxwell took care to call the energy of the currents 'electrokinetic' energy.) Any attempt to make it so appears to be a retrograde step, since most of the inertia associated with a system of currents is of electromagnetic origin. The artificiality of this hypothesis becomes, moreover, apparent when one considers that the definition of the inertia of the conduction electron would depend on the particular distribution of currents and on the position of the electron at any instant—surely a curious result.

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METALLURGY

Some Properties of Scandium Metal

SCANDIUM is one of the metals being used in an investigation into the alloying behaviour of plutonium with the metals of Group III which is being conducted at this Establishment. Since there is only limited published information on the properties of scandium itself, some experiments were undertaken on the