Eur. Phys. J. D **22**, 117–118 (2003)
DOI: 10.1140/epjd/e2002-00231-y

THE EUROPEAN
PHYSICAL JOURNAL D

Comment on

An experimental confirmation of longitudinal electrodynamic forces by N. Graneau, T. Phipps Jr, and D. Roscoe

A.E. Robson[a]

25 Clairborne Circle, Troy, Virginia 22974, USA

Eur. Phys. J. D **15**, 87 (2001)

Received 12 January 2001
Published online 10 December 2002 –

PACS. 01.55.+b General physics – 03.50.De Classical electromagnetism, Maxwell equations – 41.20.-q Applied classical electromagnetism

Ampère, in his treatise on electrodynamics [1], supposed that current elements exerted a force on each other which was directed along the line joining them, and was inversely proportional to their separation. This led him to derive a rather curious formula which, when integrated around a complete circuit, gives the same result as the more modern Biot-Savart-Lorenz law for the force on a current element within that circuit. In particular, both laws predict that the force on a current element acts at right angles to the current. It is surprising, therefore, to find persistent claims for the existence of longitudinal forces, acting in the direction of the current, and the assertion that these can be understood in terms of Ampère's electrodynamics. The most recent of these claims is by Graneau, Phipps and Roscoe [2] (GPR).

GPR report results of an experiment that is very similar to one performed earlier by Robson and Sethian [3] (RS). In both experiments, the center conductor of a coaxial circuit contained an asymmetrical element, known as the armature, which was free to move in the axial direction. When a large, pulsed current was passed through the circuit, motion of the armature would have indicated the existence of a longitudinal force. In the RS experiment the armature did not move; in the GPR experiment it did.

The experiments differed in the manner in which the current was brought into and out of the armature, as shown in Figure 1. In RS the pulsed current was fed into the side of the armature by short (0.5 mm) radial arcs. This arrangement ensured that the forces that arcs always exert on their electrodes should have no component in the axial direction, which might be confused with the longitudinal electrodynamic force. This precaution was not observed by GPR, who fed the current, also by means of arcs, into the ends of the armature. A pulsed current of tens of kiloamperes crossing an air gap of a few millimeters creates a miniature explosion and the transient pressure of the hot plasma, as well as the reaction of evaporating electrode material, gives rise to significant impulsive forces on the electrodes. This is the most likely reason for the motion of the armature in the GPR experiment. When the arc gaps were equal, the forces at the top and bottom of the armature were balanced and the armature did not move; when the lower gap was smaller than the upper, upward motion was observed, which is consistent with the more confined arc at the bottom exerting the greater pressure. No doubt anticipating this criticism, GPR performed several shots in which the armature rested on the bottom electrode, so that there was only one arc, at the top. Upward motion was observed, which GPR assert could *only* have been due to longitudinal electrodynamic forces.

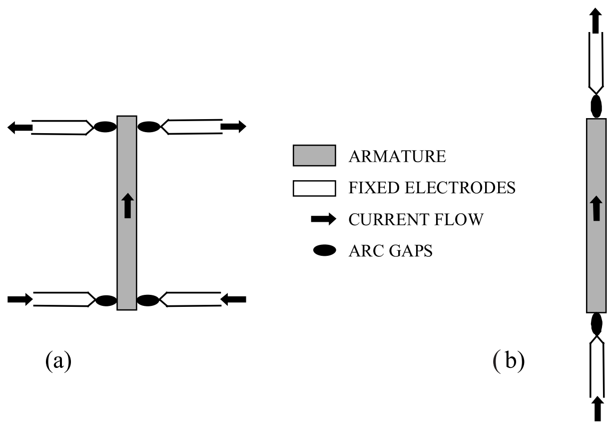

Fig. 1. Arrangements for feeding current to the armature. (a) Side connection (RS); (b) end connection (GPR).

[a] e-mail: aerobson@cstone.net

There is, however, a simple, mechanical explanation: the impulse of the arc pressure on the top of the armature gave the armature a downward momentum which, when shared with the more massive electrode structure, resulted in a reversal of the momentum vector of the lighter armature. In other words, it bounced.

To establish the presence of a longitudinal electrodynamic force in this experiment it would have been necessary to measure, or at least calculate, the longitudinal force introduced by the pressure of the arcs and subtract it from the observed force. GPR did not attempt to do this. A better approach would have been to design the experiment in such a way that arc forces could not affect the measurement. RS adopted this approach and found no evidence of a longitudinal force.

Both RS and GPR calculated the force on the armature in their respective experiments by integrating Ampère's force law round the circuit. RS calculated the longitudinal forces from different sections of the circuit and showed that their sum was zero, the expected result. The analysis of GPR led to the prediction of a longitudinal force, a result which can be traced to the deliberate exclusion of the current elements in the arc gaps from the integration round the circuit. GPR claim that the contribution of the plasma currents to the force on the armature can be ignored because the mass of the arc plasma is so much smaller than the mass of the armature. This extraordinary assertion has no basis in physics, since neither the Ampère nor the Biot-Savart-Lorenz force laws involve the mass or density of the conductor. GDR go even further by arguing that *because* it is necessary to leave out the arc current (that is, perform an incomplete integration) in order to get Ampère's law to predict a longitudinal force, and *because* they have demonstrated (or so they believe) the existence of such a force, *it follows that* the current in the arc plasma does not contribute to the force. A simpler alternative, requiring no revision of the physics curriculum, is to accept that Ampère's law, properly integrated round a circuit, does not predict a longitudinal force and to consider other explanations of the GDR observations, one of which has been suggested above.

If the longitudinal force were real, it could be used as the basis for an electric motor. The concept for such a motor is shown in Figure 2. A circuit contains an asymmetrically positioned armature which is free to move longitudinally. The sliding connections are made in whatever way the proponents of the longitudinal force believe is necessary for the manifestation of the force. The circuit is driven by a source of alternating voltage $V = V_0 \sin(\omega t)$. The longitudinal force on the armature, being proportional to the square of the current, is unidirectional and oscillates between zero and a maximum value with angular frequency 2ω. By connecting the armature to a crank and flywheel the linear reciprocating motion is converted into circular motion, in the manner of a single-acting steam engine, and useful shaft output is obtained. The electrical energy input may be calculated by considering the circuit equation which, if resistance is negligible, is simply $V = (\mathrm{d}/\mathrm{d}t)Li$ where i is the current and L is the circuit inductance.

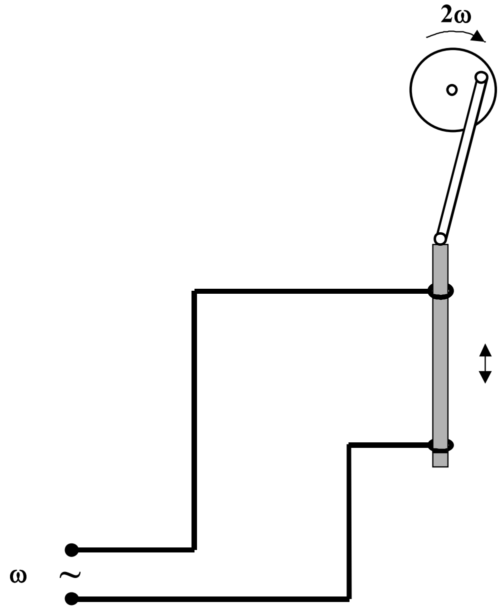

Fig. 2. A hypothetical longitudinal-force motor.

The longitudinal motion of the armature does not affect the geometry of the circuit, so L is constant and the current is given by $i = (V_0/\omega L)\cos(\omega t)$. Since the current and voltage are in quadrature, no power is drawn from the voltage source. A longitudinal-force motor would therefore give useful mechanical output with zero electrical input. There is a consensus among physicists (and patent examiners) that this is not possible.

Longitudinal electrodynamic forces do not, indeed *cannot*, exist, and all apparent manifestations of them have other, more reasonable, explanations. Nor can they be attributed to Ampère who, referring to what is known as his Third Equilibrium Experiment, stated unequivocally: "Nous tirerons de là cette conséquence générale, que l'action d'un circuit fermé, ou d'un ensemble de circuits fermés quelconques, sur un élément infiniment petit d'un courant électrique, est perpendiculaire à cet élément" [4].

References

1. A.-M. Ampère, *Théorie Mathématique des Phénomènes Électrodynamiques* (Blanchard Press, Paris, 1958)
2. N. Graneau, T. Phipps Jr, D. Roscoe, Eur. Phys. J. D **15**, 87 (2001)
3. A.E. Robson, J.D. Sethian, Am. J. Phys. **60**, 1111 (1992)
4. A.-M. Ampère, *loc. cit.*, p. 17