The Unipolar Dynamotor: A Genuine Relational Engine

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We describe two quasi trivial, "old fashioned" [1], but cleverly conceived, undisputable, experiments which disprove Kennard-type *absolutistic* interpretations of unipolar machines [2,3]. Our findings are in agreement with Weber's statements concerning the role of *relative motion* in electrodynamics [4], as advanced by himself towards the middle of the 19th century. And also we agree with Mach's views concerning motion at the most general level [5]. This work settles our earlier contributions devoted to unipolar induction [6,7]. "For nearly a century after its discovery by Faraday in 1832 the unipolar generator was a conundrum for the theory of electromagnetism"-D.F. Bartlett *et al. Phys. Rev* D **16** (12), 3459 (1977). "We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances". Isaac Newton.

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Introduction

A cylindrical conducting disk *D*, located on the pole of a permanent magnet *M*, at rest in the lab, is spun about its axis. A motional Hall effect involving Lorentz's force moves radially charge in *D*, which becomes electrically polarised and behaves as an electromotive force (*emf*) source. What happens when, remaining *D* at rest in the lab, *M* rotates in the opposite sense?

In the view of an absolutist (**A**) like Kennard, rotational motion of *M* is unable to polarise *D*. A relativist (**R**) like Weber will ensure that the phenomenon has nothing to do with absolute motion and hence he expects the *same electrical polarisation* for the same *relative motion* [8,9]

Up to now we are only considering a "two body" (*D* and *M*) problem and complications arise when we close a circuit between, say, the center of *D* and its rim. In the first case both **A** and **R** are able to explain, within their own framework, the observed fact (direct current flows through the "closing circuit" wire) since simultaneously there are both, absolute motion of *D* and relative motion between *M* and *D*. In the second case (absence of current) the observed fact is trivially expectd by **A** since for him motion of *M* cannot induce none *emf* on *D*.

The explanation of **R** runs as follows: rotation of *M* polarises *D* exactly in the same way as above. But the closing wire is also polarised in the same way and the whole circuit is acted on by two *equal* and *opossite* emf sources. In consequence, current cannot flow.

When both *D* and *M* jointly co-rotate soldered, the device works as in the first case: **A** locates on *D* the seat of *emf* generation. In the view of **R**, on the contrary, the above is untenable since *D* and *M* are at relative rest and, in consequence, the seat of emf must be located in the closing circuit (*CC*) wire, which, being stationary in the lab, is at

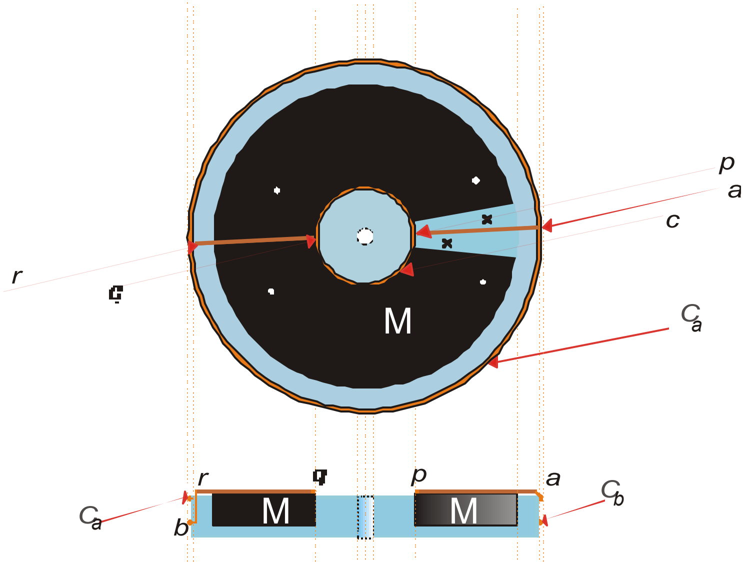


Fig. 1

Figure 1 . *M*-permanent magnet; C_a- upper copper ring; C_b- lower copper ring; *c*- inner copper ring; *ap*, *pq*- the probe copper branches.

relative motion with *M*. Closing the circuit between two different points located on the rim of *D*, no current flows. In the **R** view, the electrical potential is zero everywhere on the disk, despite being equal but different from zero at the ends of the *CC* wire. In the **A** view, the electrical potential is the same at the considered points on the disk, although different from zero.

Experimental 1. Generator

Figure 1 shows an annular (25 mm inner radius, 75 mm outer radius), ceramic-type, axially magnetized, permanent magnet *M*. A circular sector (clearest zone) amounting ca. 1/30 of the whole piece was cut out from *M*. *M* itself was embedded in a 100 mm radius teflon disk and the whole apparatus was dynamically balanced

accounting for the missing mass. The symbol • (×) labels an outgoing (ingoing) ***B*** field. The copper bars *ap*, *qr* are symmetrically soldered to *M* as shown.

The outer end *a* is welded to the upper copper ring, *Ca* anchored to the top rim of the teflon disk. Approximately 4mm below C_a, there is anchored to the teflon disk a second copper ring, C_b . A vertical wire *rb* connects the point *r* with C_b . The inner ends *p,q* remain electrically connected through a (25 mm radius) copper ring, *c*. Carbon electrodes, mounted on independent frames firmly anchored to the probe bench, are the ends of the *CC* wire and allow us to close the circuit by pressing it at the rings C_a, C_b, *c*. The electrodes can be adjusted on the proper rings with the aid of micrometric screws.

Thus, we have a five piece generator: the branches *ap*, *qr*, *rb*; the magnet *M* and the *CC* wire. We coin the name rotor (*R*) when referring to the first 4 pieces of the above device.

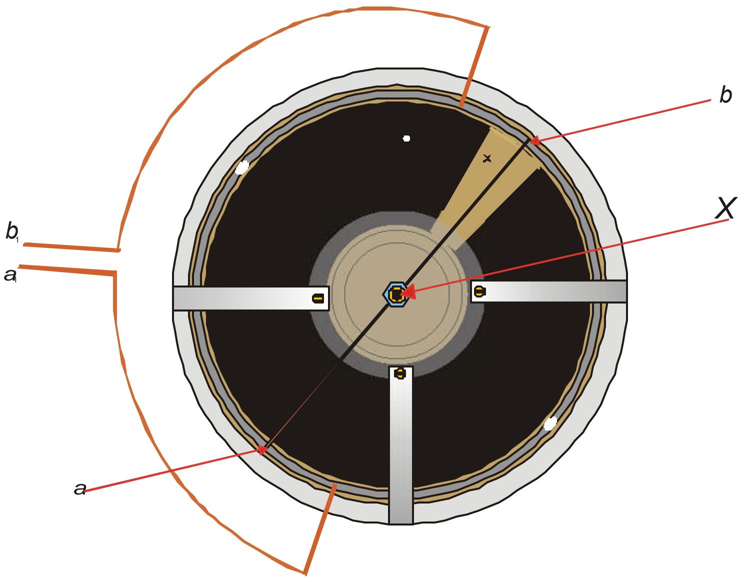


Fig. 2

Figure 2. *X*- conducting axle; *aX*, *bX*- the probe wires; *a*, *b*- the mercury channels; a_1, b_1- the closing circuit wires.

R remaining firmly anchored to the probe bench, a (80 mm radius, 1 mm thickness) brass disk, is spun clockwise (*CW*), 5 mm apart from *R*. When *w* reaches some 150 rad/s we measure, on the disk, $V_{ap}=V_a\text{-}V_p=+2.0\pm 0.1mV$; $V_{qr}=+20.0\pm 0.1mV$; $V_{ar}=+22.0\pm 0.1mV=V_{ap}+V_{qr}$. Note that $V_p=V_q$. The low voltage developped at *ap* is, of course, expected due to the eddy (Foucault-type) currents developed when the rotating disk enters into the zone in which the ***B*** field reverses its sense. The above measurement is easily improved by performing a lot of radial cuttings on the disk (the measured voltage increases). But, for our actual purposes it suffices to ensure the sign of V_{ap} . The relevant point here is to recognize that both the involved branches act as two independent *emf* generators, **oppositely polarised**, connected in series. This point will become clear when dealing with the motor configuration, in the next section. Disregarding the perturbation due to the Foucault currents, the observed facts are understood with the aid of the Lorentz force, q[(*w* x**r**)x**B**)] as applied to the moving disk.

Now we put aside the disk and enclose the rotor with a hollow brass cylinder (1mm thickness, 20 mm height) co-centered with *R*, being its rims some 2 mm apart from *R*. The cylinder is then spun *CW* and, when *w* reaches some 150 rad/s we measure, on the cylinder (at the points corresponding to C_a , C_b of *R*) $V_{rb} = 0.0 \pm 0.1\ mV$. Thus,

$$V_{ab} \approx V_{ar} \geq 22 \pm 0.1\ mV, \tag{1}$$

wherein the sign > takes into account the drop of potential at *ap* due to the eddy currents, the above being no more than an artifact, as far as unipolar generation is concerned.

Now we put *R* in *CW* rotation and, with the aid of the sliding contacts we measure differences of potential on the rings *C*, *c*. Due to the topologycal characteristics of our device, no alternating signal (due to a time-varying flux within the whole circuit) can be expected. We checked the above statement with the aid of the oscilloscope and a 600 turn circular (120 mm radius, 60 mm height,) coil axially centered with *R* . The coil enclosed *R*. symmetrically.The highest alternating (at the rotation frequency) signal measured (peak to peak) never surpassed the 50 mV, which amounts to less than 0.01 mV/turn. Nevertheless, unavoidable random noise is present due to the sliding contacts and we eliminate it by inserting a 200 *m*F capacitor. in parallel with the *CC* . All the measurements were performed with the aid of a 1MΩ impedance volt-meter. Thus, we find $V_{ap}' = -20.0 \pm 0.1\ mV$; $V_{qb}' \approx V_{qr}' = +20.0 \pm 0.1 V$; $V_{ab}' = 0.0 \pm 0.1\ mV$.

Analysis

For **A** the induction phenomenon being mainly located at the branches *ap*, *qr* of *R*, then he would expect, according to equ.1 and within the experimental error, $V_{ab}' \approx V_{ar} > 20\ mV$ and $V_{ap}' > 0$, instead of the measured $-20mV$ ones. The first inequality accounts for the lack of eddy currents in the present configuration. Briefly speaking, **A** would expect to measure the voltage developed when two *emf* sources are connected in series.

At this point, **A** becomes unable to explain the observed facts since for him the *CC* wire is no more than a *passive* element as regards induction. In the **A** view the above wire only provides an available path for charge conduction. Why does Equ.(1) no longer hold ?

In the **R** view, the induction phenomenon is based on the relative motion between *R* and the *CC* wire. All the involved rotating branches, being at rest relative to *R*, cannot develop any *emf*. The role of the above branches is only *passive*, as regards induction: they only provide an available path for charge conduction. What matters for **R** in the considered phenomenon is the motion of *R* relative to the *CC* wire. The cut in which *ap* lies only introduces a minor local perturbation in the overall spacial distribution of the ***B*** field in the space surrounding *M*, *unable to de-naturalize the main inductive phenomenon which takes place on the CC wire* In other words, the *CC* wire essentially "sees", over time, the same ***B*** field distribution. As an additional proof of the above statement, we have prepared another magnet in which the cut only amounted to 1/150 of the entire annulus surface.The outcome, as far as the reversion of ***B*** concerns, was identical to the former, albeit the original field distribution remained almost unperturbed. Thus, *R* is not surprised when reading $V_{ab}'=0$.

Experimental 2 . Motor

The figure 2 shows our former apparatus *R* in a slightly modified arrangement, available for the investigation of ponderomotive forces . Another permanent magnet *M* is now embedded in a wood cylinder whose rim locates two semicircular channels. All the above body is firmly anchored to a conducting axle *X* ended as sharp points able to rotate "quasi free" of frictional forces when pressing upon a hard, polished, glass surface. The inner ends of the conducting branches are soldered to *X*. The outer ends *a,b* are each inmersed in the proper semicircular channel filled with mercury. The whole apparatus is free to rotate in the lab around its own symmetry axis. All the involved wires are located on the north pole of *M*.

Now DC is injected from the power supply (*PS*) at a_1, being its return path a sliding wire which connects the *PS* with *X*. A continuous *CCW* rotation of the whole apparatus starts when the current reaches some 2 A. The above current ensures us the minimum force able to overcome the frictional forces, mainly due to the stationary wire/mercury contact. When reversing the current, then *R* moves in the *CW* sense.

Analysis

A view: as well as in generation, *aX* also plays the *active* role in the generation of *ponderomotive forces*. Thus, the Laplace force, $d\mathbf{F}=I(d\mathbf{l}\times\mathbf{B})$, when integrated along the entire branch, is responsible for the observed *CCW* torque. Briefly speaking, when current is flowing, **A** ensures that *aX* "drags" *M* as a whole in the *CCW* sense.

R view: as well as in generation, *M* plays the major role in the force interaction. Thus, *M* repels (attracts) *aX* in the *CCW* sense and also *attracts (repels) the CC wire in the CW sense*. Consequently, *aX* repels (attracts) *M* in the *CW* sense (Newton's third law). *aX* being

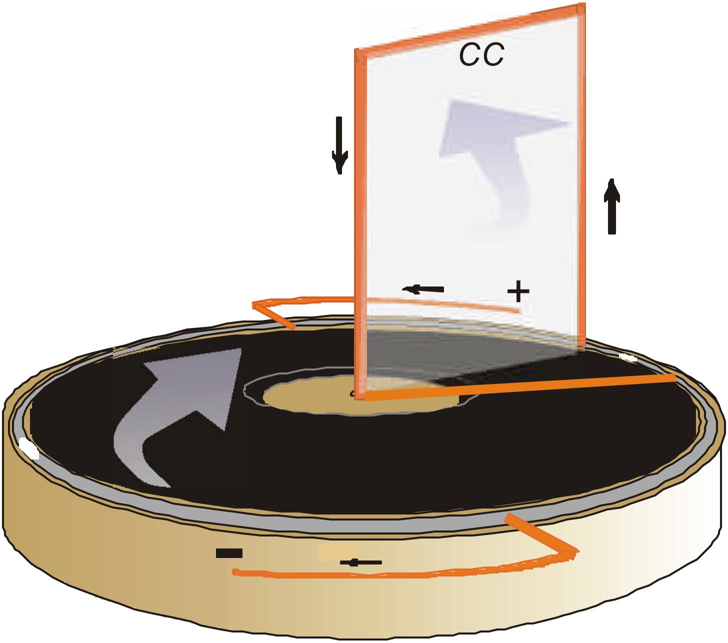


Fig. 3
Figure 3. When the magnet moves in the *CW* sense, then the rectangular closing circuit wire moves in the *CCW* sense. The horizontal branch remains soldered to the magnet.

soldered to *M*, the whole interaction *aX-M* cannot generate a rotational torque. Only remains in order to explain rotation the interaction *M-CC* wire. Briefly speaking, *M* is pushed (pulled) *CCW* by the *CC* wire. When reversing the current, then the *CC* wire moves in the *CCW* sense, whereas *M* do moves *CW*.

Figure 3 attempts to sketch the whole action of the only two torques able to produce *relative motion* between *M* and the *CC* wire.

The Laplace force being perpendicular to the current, forces acting on the mercury circular path and on the current return path cannot contribute to rotation. With the aid of the fundamental property $div\mathbf{B} = 0$ and some elementary topological considerations it is not difficult to generalize the above statement for any arbitrarily shaped *CC* wire.

Now DC is injected from the *PS* at *X*, being its return path at b_1, crossing the *bX* branch. *A continuous CW rotation of R takes place when the injected current reaches some 2 A*.

Analysis

A view: As well as in 2.1, the Laplace force acting on *bX* "drags" *M* in the *CCW* sense, with which he is unable to explain the observed facts.

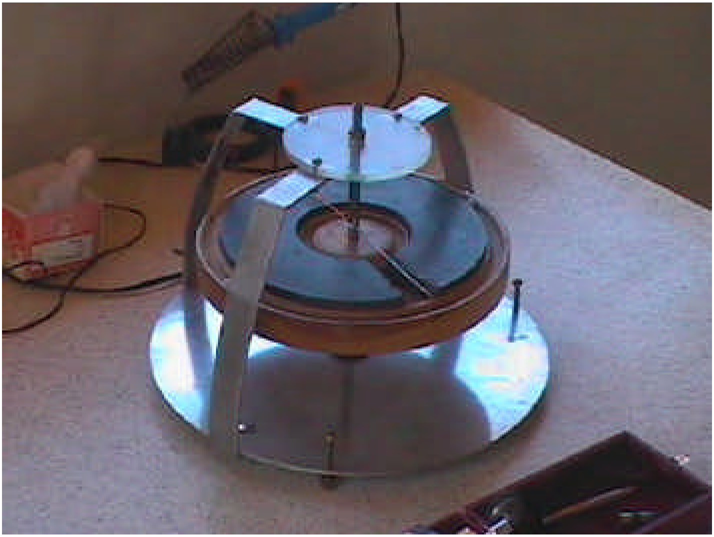
R view: As well as in 2.1, the interaction *bX-M* is unable to deliver a rotational torque and, since also *M* moves the *CC* wire in the *CCW* sense, then the *CC* wire moves *M* clockwise.

What would be expected when DC is injected at a_1 and returned at b_1?. See photo 2.

A prediction: According to 2.1 and 2.2 both the branches *aX*, *bX* are acted on by *CCW* torques and, in consequence, the same rotation as in 2.1, will take place when reaching some 2 A (note that in this configuration there are two stationary wire/mercury contacts and the whole frictional torque is twice as large as in 2.1, 2.2).

R prediction: When seeking for the *CC* wire, responsible for the rotation of *M*, he only finds some portions of the semicircular mercury channels, and the wires connecting with the *PS*, both unable to deliver any rotational torque on *M*. Therefore, rotational motion is clearly forbidden both for the magnet as for the closing circuit wires.

We failed to detect the slighest rotation when DC current was raised from 1up to 100 A.



Miscellaneous considerations

When performing the experiments described in sections 2.2, 2.3 being both the the branches *bX*, *aX* enough flexible, themselves suffered a ostensible bending **in the *CCW*** *sense*, whereas *M* moved in the *CW* sense in the first case and remained at rest in the second. This undisputable observed fact suffices to reject the "dragging effect" claimed by **A**.

We wish to point out that the matter developed in this paper has nothing to do with Special Relativity, [10] nor with the General Theory [11].

A stimulus to perform the present experiments came from the growing interest in electromagnetic phenomena [12,13,14,15,16,17,18,19,20].

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