Faraday's Electro-tonic States

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Abstract
Experimentally is shown that the field-lines of current-carrying coils or permanent-magnets are not only changed between them in case of attraction or repulsion, but also field-lines are shifted at the external ends; in case of attraction to inside and in repulsion to outside. This shift to external edges is to prove with short coils in dependent on the interval of both magnets, with long coils or magnets this effect is only indicated. With this shift of field-lines as lines of force it is possible to establish an effect of force, of course it is unknown what it is, 'the field'.

I. Faraday's and Maxwell's formulations of electro-tonic state

Faraday [1] wrote: „While the wire is subject to either volta-electric or magno-electric induction it appears to be in a peculiar state, for it resists the formation of an electrical current in it; whereas, if in its common condition, such a current would be produced; and when left uninfluenced it has the power of originating a current, a power which the wire does not possess under ordinary circumstances. This electrical condition of matter has not hitherto been recognized but it probably exerts a very important influence in many if not most of the phenomena produced by currents of electricity. For reasons which will immediately appear (71) I have, after advising with several learned friends, ventured to designate it as the electro-tonic state.“ This quotation was literally taken over by Maxwell [2].

Later Faraday had used no more the conception of electro-tonic state, since it seemed unnecessarily for him. But Maxwell [2] wrote: „The idea of the electro-tonic state, however, has not yet presented itself to my mind in such a form that its nature and properties may be clearly explained without reference to mere symbols, and therefore I propose in the following investigation to use symbols freely, and to take for granted the ordinary mathematical operations.“

Maxwell [3] wrote about Faraday's electro-tonic state: „When a conductor moves in the neighbourhood of a current of electricity, or of a magnet, or when a current or magnet near the conductor is moved, or altered in intensity, then a force acts on the conductor and produces electric tension, or a continuous current, according as the circuit is open or closed. This current is produced only by changes of the electric or magnetic phenomena surrounding the conductor, and as long as these are constant there is no observed effect on the conductor. ...“ „Considerations of this kind led Professor Faraday to connect with his discovery of the induction of electric currents the conception of a state into which all bodies are thrown by the presence of magnets and currents. ... To this state he gave the name of the 'Electro-tonic State',... .“

Maxwell [4] wrote: „Thus if we strew iron filings on paper near a magnet, each filing will be magnetized by induction, and the consecutive filings will unite by their opposite poles, so as to form fibres, and these fibres will indicate the direction of the lines of force. The beautiful illustration of the presence of magnetic force afforded by this experiment, naturally tends to make us think of the lines of force as something real, and as indicating something more than the mere resultant of two forces, whose seat of action is at a distance, and which do not exist there at all until a magnet is places in that part of the field. We are dissatisfied with the explanation founded on the hypothesis of attractive and repellent force directed towards the magnetic poles even though we may have satisfied ourselves that the phenomenon is in strict accordance with that hypothesis, and we cannot help thinking that in every place where we find these lines of force, some physical state or action must exist in sufficient energy to produce the actual phenomena.“

It is intelligible that for Maxwell the interpretation of constant electric and magnetic phenomena are necessary, for Maxwell's equations respected only phenomena in variable fields.

Faraday spoke of lines of force, Maxwell also of lines of induction, today is usual the term lines of field. Maxwell [5] called attention especially to the structure of vortices of electric and magnetic phenomena. He wrote: „I have found great difficulty in conceiving of the existence of vortices in a medium, side by side, revolving in the same direction about parallel axes. The contiguous portions of consecutive vortices must be moving in opposite directions; and it is difficult to understand how the motion of one part of the medium can coexist with, and even produce, an opposite motion of a part in contact with it." (According Maxwell 's equations the curl of field is in every point of a variable field unequal zero!) „The only conception which has at all aided me in conceiving of this kind of motion is that of the vortices being separated by a layer of particles, revolving each on its own axis in the opposite direction to that of the vortices so that the contiguous surfaces of the particles and of the vortices have the same motion." For today in practice the theory of continuum is given up, so the difficulty of friction-particle is avoided. Maxwell [5] wrote further: „The centrifugal force of these vortices produces pressures distributed in such a way that the final effect is a force identical in direction and magnitude with which we observe."

Later Maxwell gave up the mechanical interpretation of his theory, but not the molecular-vortices as source of magnetic field and the electro-tonic states. Hoppe [6] described the state of theory of vortices before Faraday and Maxwell.

Einstein [7] established that formerly the field was not due to the property of inertia, this remained wrapped in darkness. He wrote (translated): „The deliverance out of this unpleasant condition by Faraday's and Maxwell's theory of electrical field means indeed the profoundest revolution which the system of physics had experienced since Newton. This is again a step in direction of constructional speculation, which enlarged the distance between foundation of theory and the sensual ability of experience. The existence of field manifested namely only then when electric charged bodies are brought in that place. Maxwell's differential-equations connect the spatial and temporal differential-quotient of electrical and magnetical fields." Einstein [8] wrote in a message to the 100th birthday of Lorentz (translated): „Seat of the electromagnetic field is the vacant room. In it there is only one electric and one magnetic field-vector. This field is produced by atomic electric charges, upon which the field react ponderomotorically." Still today is wrapped in darkness, how this occurs.

Here are executed only experiments with lines of force in static magnetic field from which was to expect a contribution to Faraday's electro-tonic fields. Quantitative results are not aspired. Here should be possible also the term magneto-tonic state. But the notion of Faraday's electro-tonic state is reaching much farther.

II. Experiments with current-carrying coils

A plastics-tube 25 mm diameter and 25 mm long was winding two-layered with lacquer-enamelled copper-wire ϕ 0.5 mm. In figure 1 a was standing a second coil in a distance of 12.5 mm with opposite

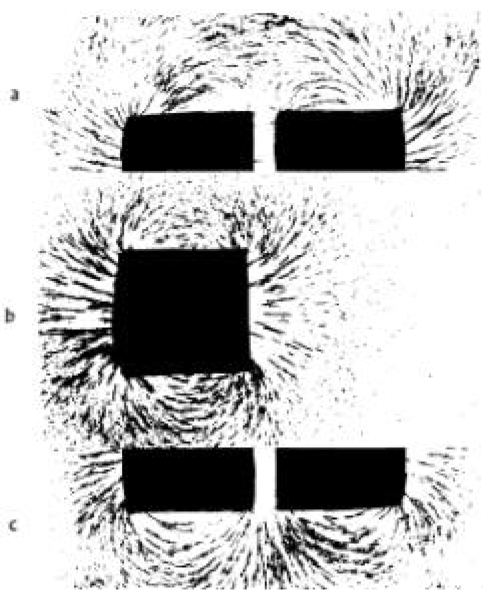
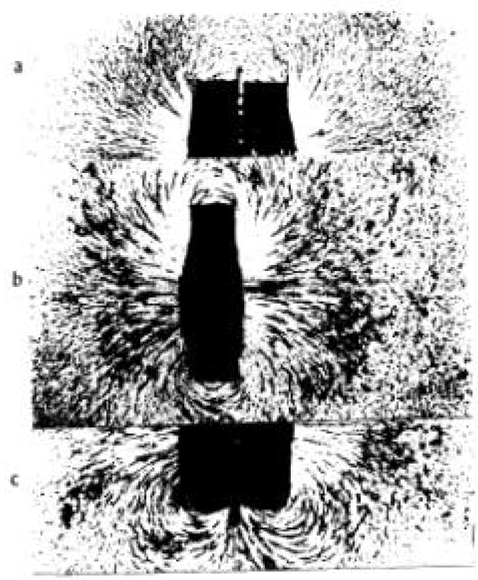


Figure 1. Images of field-lines of coils in an interval of 12.5 mm,
a: in case of attraction (upper part),
b: field-lines of one coil,
c: in case of repulsion (under part).

polarity, therefore in the case of attraction. Figure 1 b shows the field-lines of one coil. The field-lines as vortex-field is manifested here. In the figure 1 c the same poles of the coils are turned towards, that is the case of repulsion. All coils are carried on with direct-current of 1 A. These are the known pictures with vortex-structure as shown in every textbook, reversion of polarity of one coil changes the field-lines in the sphere between the coils. But the figures a and c indicate that also on the outer ends field-lines are trifling shifted. For general should be demonstrated a homogen field, so were used long coils in ratio to diameter where this effect is nearly imperceptible. In the next section are used



shorter coils for there this effect should be more distinct. The variation of current from 1 A to 4 A does not change noticeably the direction of iron filings, only iron filings are more distinct for the filings are stronger lump together.

Figure 2. Images of field-lines of circle-currents in an interval of 2 mm.
a: in case of attraction (upper part),
b: field-lines of one circle-current,
c: in case of repulsion (under part).

III. Experiments with current-carrying circle-bundles

Here are used wire-bundles with 50 windings wound of copper-lacquer-wire f 0.6 mm with an average diameter of 27.5 mm. Fig 2 a shows the pictures of field-tines in 1 mm distance of two circle-bundles in the case of attraction. Fig 2 b shows the field-lines of one bundle, figure 2 c the arrangement in repulsion. Now is manifested that not only the field between the coils is changed but also on both outer ends. In the case of attraction the field-lines are not only united but shifted to inside. In the case of repulsion the field-lines are not only separated but also shifted to outside. Also opposite one single coil the field-lines are shifted.

The figure 3 shows some field-lines of the three cases drew one upon another, the circuit-bundles had a distance of 5 mm.

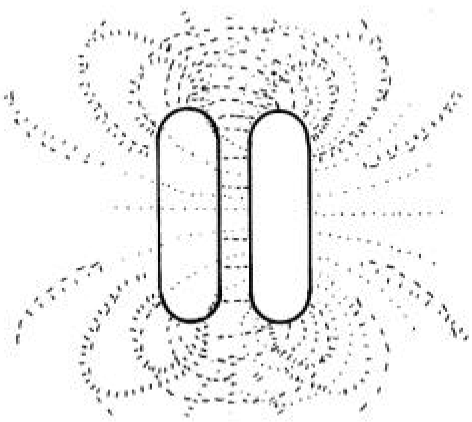


Figure 3. Selected field-lines of circle-currents in an interval of 5 mm,
- - - case of attraction,
. . . only one circle,
| | | case of repulsion.

IV. Experiments with permanent-magnets

The used permanent-magnets had a diameter of 15 mm with a bore-hole of 5 mm and a length of 12 mm. Fig 4 a show the field-lines of two magnets in distance of 2 mm in the case of attraction. Fig 4 b shows the field-lines of one single magnet. In figure 4 c the two magnets are arranged opposite two equal poles. Here also is to see the searched effect: the field-lines do not change their direction not only between the two magnets but also at the outer ends. The whole field-lines are shifted in attraction to interior and in repulsion to exterior.

V. Discussion

These experiments show that the whole field-lines are shifted at a reversion and not only

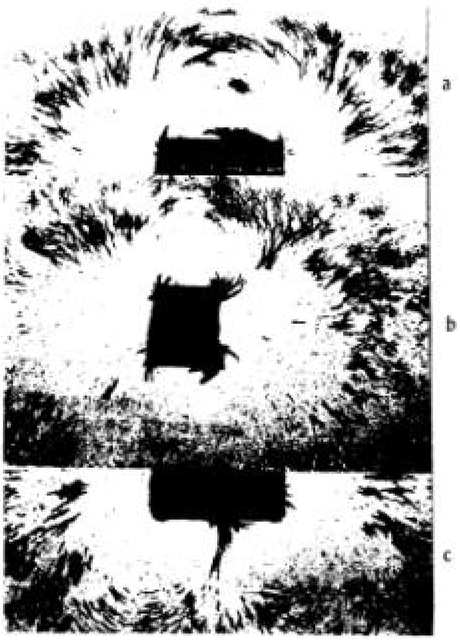


Figure 4. Images of field-lines of permanent-magnets in an interval of 2 mm,
a: case of attraction (upper part),
b: only one magnet,
c: case of repulsion (under part).

between two coils but also at the exterior ends. Thereby is to consider that field-lines yields out of a sum of circuit-currents or elementary-magnets, therefore this effect is less at long coils or magnets. As already marked, the direction of field-lines is not noticeable dependent on current intensity or magnetization but from the distance of magnets, also at the exterior ends. Otherwise, if one goes out of the idealization those field-lines start from one pole and return to the other, so the field in case of repulsion returns behind the exterior poles. In case of attraction the field run to a sphere before the inner poles.

Out of the appearance of shifting of field-lines or the by them formed tubes, about their focal-point (or corresponding the distance modified centres) as lines of force, the effect of force is to establish if strength of field is respected. Maxwell [5] supposed pressures produced by centrifugal force of vortices of ether.

That in case of normal conducting coils the magnetic moment of electrons are straightened, is not to suppose, for they are submit many impacts. Only magnetic sheets are formed by current-carrying coils. Differently with two super conducting coils. Here a straighten of magnetic moment of circulating electrons is thinkable, by Nieke [9] is formed ever a magnetic moment-sheet.

Hoppe [6] reported that Gilbert considered magnetism as committed vortex-force and accepted only attraction as strive for association, repulsion he discussed as turning. With it the gravity has no exceptional position. Certain Faraday this gave up to preserve the analogy to electrical charge.

The description of the presented experiments by shifting of lines of force gives a possibility of description, a real establishment wrecked for we do not know what it is 'the field'. The presented experiments give to this no additional information. By Faraday [1] the field is a state of tension, by Maxwell [4] a beautiful illustration; by Einstein [7] a constructional speculation. If loosen in pairs: by Hertz electro-magnetic radiation, by Nieke [11] decaying in self-acting photons, ...

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