

FARADAY'S DIARY

Being the Various Philosophical Notes
of Experimental Investigation

made by

MICHAEL FARADAY
D.C.L., F.R.S.

during the years 1820-1862
and bequeathed by him to the

ROYAL INSTITUTION OF GREAT BRITAIN

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Director of the Laboratory of the
Royal Institution

VOL. I

SEPT., 1820-JUNE 11, 1832

LONDON
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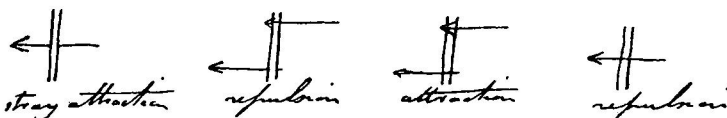
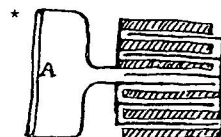
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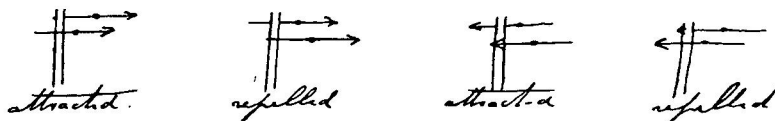
Electromagnetic expts. with Hare's Calorimotor. To be re-
membered that this is a single series?

ELECTRO-
MAGNETISM.

1. Position of the expt. wire A*.
2. Positions at first ascertained were as follows



3. On examining these more minutely found that each pole had 4 positions, 2 of attraction and 2 of repulsion, thus



4. Or looking from above down on to sections of the wire



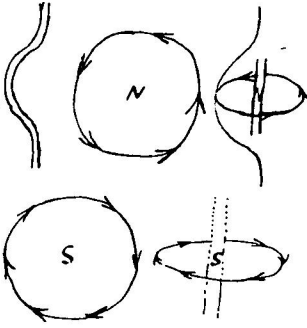
5. Or



6. These indicate motions in circles round each pole, thus



Hence the wire moves in opposite circles round each pole and/or the poles move in opposite circles round the wire. To establish the motion of the wire a connecting piece was placed upright in a cork on water; its lower end dipped into a little basin of mercury in the water and its upper entered into a little inverted silver cup containing a globule of mercury; the arrangement of battery poles always as at first. Magnets of different



power brought perpendicularly to this wire did not make it revolve as Dr. Wollaston expected, but thrust it from side to side. 8, 9. The wire then bent into a crank form, thus, and by repeated applications of the poles of the magnets the following motions were ascertained, looking from above down on the circle described by the bent part of the wire, different Magnetic poles shewn by letters, North pole in centre. The rod in the circle is merely put there to shew the front and back part.

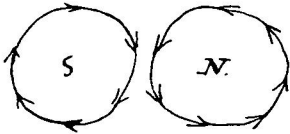
10. Magnetic poles on the outside of the circle the wire described*.

11. The effort of the wire is always to pass off at a right angle from the pole, indeed to go in a circle round it; so when either pole was brought up to the wire perpendicular to it and to the radius of the circle it described, there was neither attraction nor repulsion; but the moment the pole varied in the slightest manner either in or out the wire moved one way or the other.

12. The poles of the magnet act on the bent wire in all positions and not in the direction *only* of any axis of the magnet, so that the current can hardly be cylindrical or arranged round the axis of a cylinder?

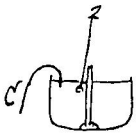
13. From the motion above a single magnet pole in the centre of one of the circles should make the wire continually turn round. Arranged a magnet needle in a glass tube with mercury about it and by a cork, water, etc. supported a connecting wire so that the upper end should go into the silver cup and its mercury and the lower move in the channel of mercury round the pole of the needle. The battery arranged with the wire as before. In this way got the revolution of the wire round the pole of the magnet. The direction was as follows, looking from above down [see diagram].

Very Satisfactory, but make more sensible apparatus.

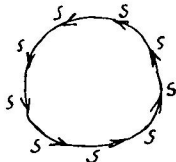


TUESDAY, SEPT. 4.

14, 15†. Apparatus for revolution of wire and magnet. A deep basin with bit of wax at bottom and then filled with mercury, a Magnet stuck upright in wax so that pole just above the surface of mercury, then piece of wire floated by cork, at lower end



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† [14, 15]



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* [16] A



dipping into mercury and above into silver cup as before, and confined by wire or capillary attraction from leaving the M. Pole. 16*. Now Magnet round wire. The magnet had one pole so far sunk by platinum as to be low under the surface, leaving the other just above the surface whilst the whole floated; then the wire of connection was made to dip into the mercury near the pole.

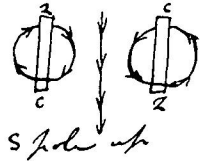
17. The Magnet Pole floating between the two wires in the mercury proceeds one way or the other in a right line between them; or the other way if north pole up.

18. But when the two wires are from the same pole the magnet is unacted upon between them.

19. Could not make the Magnet or wire in the center turn round its own axis—but if the revolution depends on the motions of the currents essentially and not on the conductors except as the media, then perhaps those currents in the axis may turn without the media whilst those in the circumference cannot.

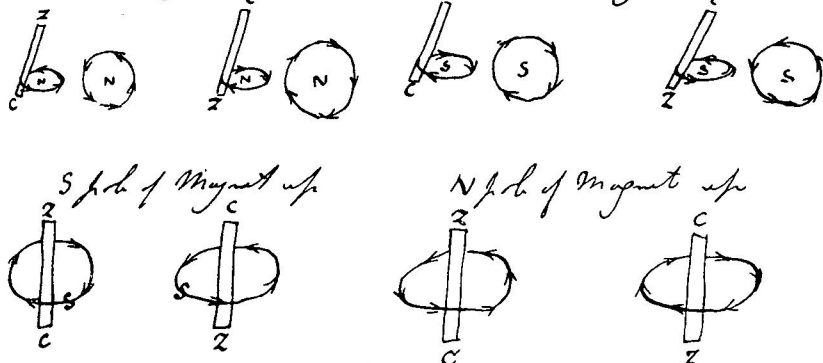
20. Every thing tends to prove that there is no attraction between the poles of the magnet and the wire, but only motion in a circular direction, and all the motions of the magnet or its poles about the wires may be deduced from this. When the single pole was floating upon the mercury it shewed it both by revolving round single wires and passing through double ones.

21. On floating a magnet horizontally on water at the bottom of which was mercury to connect the wires any where, the apparent attraction and repulsion of the poles were all reduced into the two circular motions about the wires. Hence also the reason why the magnet, when the connection is made, obeys both wires, taking a position exactly between them and with the poles as far as possible from the wire. It then goes to the nearest wire, but not by either pole but by its central point. And if the pole be put to the wire and slightly agitated the magnet will slip along the wire till midway across it.



* [16] N pole of Magnet up.

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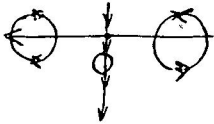
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ELECTRO-MAGNETISM.



22. Perhaps the settling of the needle perpendicular to the wire across it and then its approach on that side and its passing off on the other is the most instructive instance of attraction and repulsion. It is shewn that the attraction and repulsion, as they seem to be, are only the combined action of the two circles in which the poles endeavour to move round the wire, and two poles of different magnets, which alone merely tend to revolve round the wire in different directions, will, if tied together at a little distance from each other by a piece of thread, exhibit all the phenomena of attraction and repulsion that a complete magnet does.

23. The indifferent state of Mag. pole and absence of axis is shewn by the wire revolving in all directions about it.

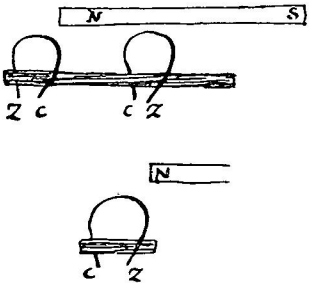
24. The double curve, each part goes the same way with the same pole and different ways with different poles, make revolv. the same way though on opposite sides of the wire. This strengthens the idea that it is not the wires but the currents that revolve, and shew[s] that it is not this or that side of the wire that has any relation to the pole, but the position of the current to the pole itself.

25. A magnet made part of the circuit shewed no difference of property by other magnets or wires. Except that it took up filings only at the poles when unconnected but all over when connected, dropping part when connection broken. The two Magnetisms do not seem to interfere; nevertheless there must be some effect. Try weak magnet.

S
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SEPT. 5TH, 1821.

26*. Expts. with De la Rive's Curve. The shaded bars are merely to show the position of the curves.

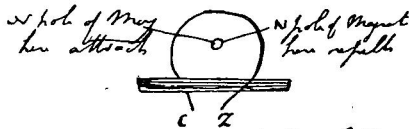


If the Mag. pole be above the curve there are particular positions as follows:

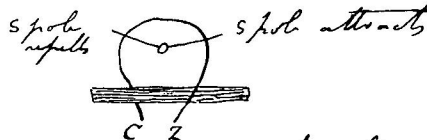
27. Rest in these positions, but if the part N be carried nearer to either of the curves they will move from it—the effect is for the curve to rise up and go over the N.

28. Here if N is exactly perpendicular to the plane of the curve it will attract it; if rather oblique to it it will turn the curve round and then repel it.

* [26]



i.e. curve moves to left hand when N pole in centre



i.e. curve moves to right hand when S pole in centre

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29. Here the curve will move towards N if quite perpendicular to it (i.e. the plane); if oblique it will turn round and then be repelled from N a little this way [towards the right].

So that here all the effects are evidently owing to the effort made by the wire to revolve round the pole or the pole round the wire, and does not at all relate to the whole magnet, i.e. to both poles at once.

30, 31*. The curve placed in either of the dotted positions will take the central position and rest there. If the central position be reversed the curve will still rest there, but if ever so little on one or the other side of the centre it will pass that way from off the wire and be repelled, or if some slight cause make it oblique it will turn round and then go on, again taking up the position actually marked.

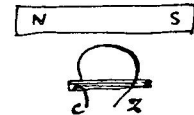
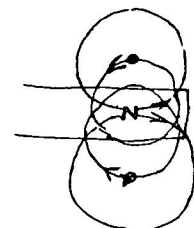
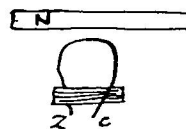
32. This an horizontal section of the magnet and curve, the two dots being the sides; the curves shew the way in which the wires and the pole endeavour to move and therefore the arrows heads represent the forces which are drawing the curve over the magnet or the magnet through the wire.

33. The tendency of a magnet or needle therefore is to go to the centre of the curve or helice, and a strong curve or helice ought to hold a needle just in its centre.

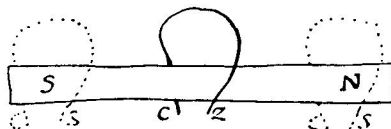
34. Magnet above the curve is the reverse of the Magnet through the curve.

35. Expts. to ascertain if Helice or curve would suspend a magnet. A magnet was corked so as just to sink in water. Then a helice constructed of Haberdasher's wire covered with cotton, round a glass tube, the curves being close; this connected and brought near the magnet in the water. The two mouths of the tube attracted and repelled the ends of the needle, and when attraction took place the needle entered quit[e] into the tube and took its place in the middle. If moved out at either end it returned again into the tube. But if when taken out it was turned round and then put into either end of the tube it was repelled or thrown

36. out at one or the other end according to its vicinity. Hence its natural state in the tube was with similar poles together, and its repulsive state with different poles together—the effect depends



* [30, 31]



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ELECTRO-MAGNETISM.

on its effort to carry the poles round the sides of the cylinder or helice as round the wire.

37. See if a natural cylindrical magnet will do this.

These are the same results as with De la Rive's curve and Magnet of Morning.

SEPT. 6TH.

Expts. on Direction of curve by the earth.

36.¹ Made a single combination and connected by copper wire in curve form; put this into a small jar with acid as a cell and put that jar on water to float. It very slowly arranged itself with curve perpendicular to the mag. meridian, and then a south pole attracted the inside of the curve towards the north. Repeated, same result. Curve about 4 inches in diameter, plate zinc about 4 square inches.

37.¹ De la Rive's little curve apparatus put into neck of a florence flask stopped and floated and with little acid; then on water just as upper. It very soon took direction perpendicular to Mag. Mer., and the side towards the N was attracted to south pole. It even oscillated about this position slowly.

38. Single curve helice of silked copper acted on a magnet just floating in water as might be expected from expts. of yesterday.

39. Silked copper wire—a close helice formed on a glass tube about half an inch diameter, the wire bell wire, and one end taken through the tube so as to connect, etc.

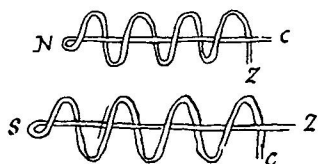
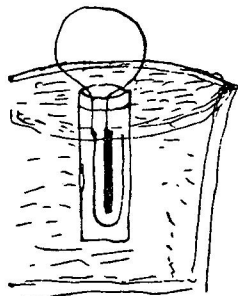
40. This acts at the external end on revolving wire, i.e. connecting wire exactly like magnet.

41. Its pole attracts and repels in 4 positions like magnet pole.

42. When its action on a needle is compared with that of the similar pole of a magnet it is perfectly similar except in one position, as in margin; in this it seems as if the helice repelled the needle, but in this way the Magnet attracts. The effect appears to be due to the separate state of the currents, which allows a little action in the opposite direction. This is shewn by effect of imitation of magnet by a plate bent: see farther on.

43. A double or two currents in different ways made of silked wire act just like a compressed helice: one crevice attracts but at the side repels; the other crevice repels but at the side attracts.

¹ In the MS. nos. 36 and 37 are repeated.



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44. Two currents in same direction together act just as one does. Has 4 positions to the needle, etc. just as one current has.
45. Tried a long slip of copper, edges only active; it had the same effect as many currents (same) side by side, or rather as one broad flat current. Form of revolutions about it of course altered.
46. Another plate of copper, the middle bent nearly into a cylinder and then connected; was like the slip made into a cylinder, but long and narrow. This connected at two edges with mercury and battery the cylinder part acted just like a magnet and had two poles.
47. A square piece of copper connected at corners acted as a plate, but grew weaker from centre to side corner where the action was weakest.
48. The advantage of a helice consists in neutralising the central part between the poles and getting the poles separate. Hence in using strips of metal, the reason why edges only act because the circuits in the other parts are in the same direction and neutralise.

Is a single curve as strong as a helice?

SEPT. 7TH, 1821.

49. Attempted to make a straight wire direct by the earth, extending it from one basin of mercury to another, supporting its weight by water above and cork floats, but mercury foul and surface skinned so as to prevent motion.
50. Endeavoured also to make it rise and fall by position to the earth, as it actually did do to a north pole of a magnet to the north of it when the connection was made and broken; but could get no distinct effects.
51. Made a copper helice to repeat the expts. with the iron one of yesterday. Results were the same except that the magnetising power was so strong as quickly to change the polarity of the needle when reversed in the helice, and the repulsion soon became attraction.
52. Single curve not so strong as compound helice; the bands of metal act through each other and appear to concentrate in what has been called the pole.
53. A needle made to float with one pole up then brought under



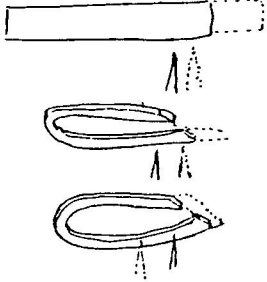
ELECTRO-
MAGNETISM.

the opposite pole of a magnet. It always pointed to a point in the axis not at the end but some little distance in from it, so that pole is not at the end.

54. The helice turned the same way agrees with the magnet except that the needle always points towards the end of the axis than to a part a little way up it; at least this is the case the needle being on the outside. Perhaps it is owing to the separate rings, to the tubular end and to want of solidity in the helice, which do not exist in the magnet.

SEPT. 8, 1821.

MAGNETISM.



Expts. on position of pole in Magnet.

Pole of needle floated, bar magnet brought over. Needle rested under the true pole. Piece of soft iron put to the magnet end, pole immediately moved towards the end.

One pole of horse shoe magnet brought over the needle: position of pole ascertained. Piece of iron put on, pole approached the end instantly. The iron made to connect both poles the needle, i.e. the poles, then moved the other way and became weaker.

On making the contacts better the effects all stronger, and if they had been perfect with the horse shoe magnet the polarity would probably have ceased altogether. Contact by other metals produces no effects of this kind; that¹ of course it is not the position in which it should be expected.

These expts. favour the current view, but they seem to shew that the difference between the helice and the magnet of yesterday (54) do not depend on the causes there mentioned, for I made a solid helice of small wire, but still the tendency to end quite as strong as before. It probably depends on the electromotive power within the magnet being by induction stronger in the middle part than elsewhere, and therefore the poles, being situated relatively to the whole power, will be within; the movement of the pole both in the single and horse shoe magnet favours this view. Query the best form for a magnet, i.e. so that the pole may be nearest the surface: an oblate or oblong spheroid or a sphere or a very thick ring?

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SEPT. 8, 1821.

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A helice disk made, N. P. centre of one side, S. P. centre of the other—compare with steel plate similarly magnetised in centre. Query opposite poles. MAGNETISM.

SEPT. 10, 1821.

2 Equal magnets (needle): 2 separate poles take up certain quantity of filings—2 similar poles together take up as much—2 different poles do not take up near so much.

2 similar poles, though they repel at most distances, attract at very small distance and adhere. Query why.

Large magnets, repelling poles attract at very small distances.

Flat spiral very active; attracts and repels same pole on different sides; takes up very much filings; strongest at centre. ELECTRO-MAGNETISM.

Do. not complete: to centre like former, but very beautiful with Iron filings.

Filings on paper over Helice arranged from one pole to the other in curves like as over magnet.

On Paper over spirals very beautiful indication of course of action.

Hollow Cylindrical Magnet would not draw needle through like the helice, but the pole of the needle always attracted by same pole of magnet.

Filings from bottom of hollow cylindrical magnet do not arrange as from hollow helice; they diverge both ways from the edge, but from the helice only outwards from the centre.

Could not magnetise a plate of steel so as to resemble flat spiral; either the magnetism would be very weak and irregular or there would be none at all.