

II. *A collection of the magnetical Experiments communicated to the Royal Society by Gowin Knight M. B. & F. R. S. in the Years 1746 and 1747.*

I.

An account of some magnetical Experiments, exhibited before the Royal Society on Thursday the 19th of February 1746, and of which the President, who had before seen the same performed with more deliberation on the 11th of the same month, was pleased to make the following report.

Read Feb. 19.
1746-7.

B EING on *Wednesday* the 11th of this instant *February* at the house of Mr. *Knight*, I did there in company with our worthy brother *William Jones Esq;* see the following experiments; which Mr. *Knight* was desirous I should, as on this day, report to the *Society*: before whom he is also now prepared to exhibit the same, as well as the circumstances of the place and the number of the company will allow.

He first produced two almost equal bars of hardened steel, to which he had communicated a strong magnetic virtue. These bars were nearly square, each being of the length of about 15 inches and two tenths, and of the breadth and thickness of a little more than half an inch: one of these
bars

bars weighed 2 pounds and 6 pennyweight *Troy*, the other 4 pennyweight less than 2 pounds; and either of them readily lifted with one of its ends better than 3 pounds and a half.

These bars were then laid down on a table, so as to be nearly in one and the same strait line, the north pole of the one being next to the south pole of the other, and at the distance of about an inch from it: that is to say, that the north poles of both bars were pointed the same way, but without any regard to the position of the natural meridian.

Mr. *Knight* then produced a piece of natural magnet, which was one of the same he had formerly made use of, in some experiments he had before shewed to the *Royal Society*. This piece was in length an inch and $\frac{1}{10}$, in breadth $\frac{7}{16}$, and in thickness about $\frac{3}{16}$ of an inch at a medium, being considerably thicker at the one end than at the other.

This piece of magnet was then applied, so as to lie between the 2 first mentioned bars, with its thin end close to the north pole of one of them, and its thick end close to the south pole of the other. After it had lain in this position a few moments, it was taken out, and upon presenting it to the magnetic needle of a small compass box, it was observed that its thinner end, the same which had just been contiguous to the north pole of one of the bars, attracted the north end of the needle; and that the thicker end, the same which had been contiguous to south pole of the other bar, attracted the south end of the same needle.

This same piece of stone was then again put in between the bars, but in a contrary position; the thicker end now lying next to the north pole of one of

the bars, and the thinner end next to the south pole of the other. After a few moments it was again taken out, and presented as before to the compass-box: when it was found that the thinn end now attracted the south end of the magnetic needle, and that the thicker end attracted the north end of the same.

The piece of stone was then again placed between the bars as at the first, and being again taken out and presented to the compass-box: the thin end was again found as at the first to draw the north end, and the thick end to draw the south end of the needle.

This same piece of magnet was then again placed between the bars, but in a position at right angles to both the former, one of its sides being now contiguous to the north pole of one of the bars, and its other side to the south pole of the other. After which being again in a few moments taken out, and presented to the compass-box as before; it was found that the side which had been in contact with the north pole of one of the bars, did attract the north end of the needle, and that the other side which had been in contact with the south pole of the other bar, did attract the south end of the same needle: whilst the two ends of the stone in which the polarity was before observed, were now found to be indifferent to either end of the needle; so that the line of direction of the poles in the stone now lay at right angles to the position in which it was situated in the former experiments.

Mr. *Knight* then produced two steel needles, of the same sort as those which are usually fixed to the cards of sea-compasses. These needles were of the length of 5 inches and $\frac{3}{16}$, and weighed severally with their caps 7 pennyweight eight, and 7 pennyweight.

weight nine grains; one of these was tempered and of a blew colour, and the other was quite hard. He also produced two iron weights, severally weighing 14 pennyweight 22 grains, and 15 pennyweight 7 grains, both nearly of a cylindrical form, but with one of the ends rounded off.

The 2 large bars were then placed in a line, as in the former experiments, but with their ends so near together, as only to admit of the cap of one the needles between them.

The tempered needle was then placed flat upon the bars so that nearly one half of it rested upon one bar, and the other half upon the other, the cap lying between the two. The needle was pressed close to the bars in this position, after which the bars were drawn away, both at the same time contrarywise, till they were clear of the needle; and this operation was repeated three or four times: after which that end of the needle which had rested upon the northern part of one of the bars, was found strongly to attract the north end of the needle in the compass-box; and the other end which had rested upon the southern part of the other bar, was found to attract in like manner the south end of the same needle in the box. The power of attraction also acquired by this needle appeared to be very considerable, it lifting easily with either of its ends, the two iron weights above mentioned, when cemented the one to the other with wax, and weighing together 1 ounce 10 pennyweights 5 grains.

The hard needle was then applied to the bars like the other and with the very same success, it lifted also, as the other had done, both the weights together.

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The two needles were then themselves applied to each other, first the northern half of the one, in a contrary direction, to the northern half of the other; and then the southern half of the first, in a like contrary direction to the southern half of the last; and from these several positions, they were severally drawn till they were clear of each other, and this several times successively: after which operation it was found, that the tempered needle had lost so far its virtue, that its northern end had hardly any effect upon the needle in the box; that its southern end even began to attract the contrary end of the needle from what it did before, and that it was no longer able to lift at either of its ends any sensible weight.

But as to the hard needle, that still retained a considerable share of its former virtue; its ends still strongly drawing the same ends of the needle in the compass-box as they drew before, and either of them lifting with ease the heavier of the two above-mentioned weights.

Mr. *Knight* then produced one of his common small magnetic bars; the which being applied to the forementioned large bars, in the same manner as the needles had been applied to the same, but in a position contrary to that of its present polarity, it had its poles thereby counterchanged or inverted, and was found to lift at that which was now become its northern end, the weight of 6 ounces 8 penny-weight and 5 grains.

He lastly produced one of his large artificial armed magnets, composed of several thin plates of steel cramped together, with which he acquainted us he had some time before lifted 36 pounds,
and

and with which he did now actually lift before us 3 1 pounds 9 ounces and three fourths.

The temper'd needle spoken of above, and which had nearly lost all its virtue, had the same again restored in great measure, upon being touched in the common way, on the armed poles of this artificial magnet; after which it discovered a strong verticity, and was able to lift at one of its ends, the heavier of the 2 abovementioned weights, that is to say somewhat more than three quarters of an ounce.

The hard needle which still retained, as has been observed, a considerable part of the virtue it had acquired by the touch of the large steel bars, was lastly touched also in a contrary sense, upon the armed poles of this artificial magnet; whereby it not only lost the polarity yet remaining, but acquired a new one the other way, it would not however after this last touch lift more than nine pennyweight.

This is the true substance of the minutes I took, when these experiments were made, and which I presume will now be verified by those Mr. *Knight* is here prepared to shew.

AFTER the reading of this report, Mr. *Knight* did accordingly produce before the *Society* the two large bars and all the other particulars therein mentioned, with which he publicly repeated all the same experiments; which notwithstanding the disadvantageous circumstances of the place, succeeded perfectly in every particular, and to the entire satisfaction of all the company.

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It was then further proposed, that the temper'd needle, having its virtue again destroyed, should be touched upon the fine armed *Terella* belonging to the *Society*, which was the noble present of their late worthy member the Right Honourable *James* Earl of *Abercorn*, which is esteemed one of the best in *England*, and is said to have lifted in his Lordship's hands upwards of 40 pounds: the same was immediately brought, and the needle being touched therewith, was found to have acquired a strong polarity, and to lift about the same weight, as when it was before touched upon Mr. *Knight's* large armed artificial magnet; that is to say about fifteen penny-weight.

II.

An Account of some new Experiments lately made with Artificial Magnets, by the same.

June 4, 1747.

Read July 2. 1747. **T**HE *Apparatus* for touching of Needles, which I sometime since had the Honour to shew before the *Royal Society*, was as perfect as I could have wish'd, as far as relates to the intended Use of it: But the manner in which the two Bars were disposed in their Cases made the Length of them something incommodious, especially in those of the largest Size. This made me desirous of trying if some Method could not be found out of placing the Bars parallel to each other without Danger of weakening their Force, by which means the Cases would be reduced to half their Length. I remembered that some Years ago,

ago I had tried some Experiments to this Purpose, by placing some Bars parallel and in Contact, but so that their Poles were turned different ways: in which Position I found the Virtue of some of them remain'd pretty entire, but that others were weakened thereby. I imagin'd the Reason of their losing their Force was this; that the magnetic Virtue was by degrees habituated to pass out of the Side of one Bar into that of the other in Contact with it, and thereby was hinder'd from arriving at the Ends in its full Vigour. The Reason why some suffer'd more than others was doubtless to be ascrib'd to their Difference in Temper. I repeated the Experiment about two Months ago, with a little Alteration. I placed the Bars parallel with their Poles in an alternate Position, as before, but not in Contact, having kept them at the Distance of about a Quarter of an Inch. Then I apply'd to their Ends two Pieces of soft Iron. Each Piece was laid across from the North End of one Bar to the South of the other, in the same manner as the Lifter is applied to the Feet of an armed Loadstone. The Intent of this was to draw the magnetic Virtue thereby down to the Ends of the Bars, and to convey it through the Pieces of Iron from one to the other. In this Condition I let them lie for about a Month, and then tried if they would lift the same Weight as before, which I found they did, and I thought with more Vigour. After this I repeated the Experiment with other Bars of various Sizes, and with the same Success: I have therefore now ventur'd to fit them up in Cases in the manner just described.

The Success of this Experiment had led me to another Improvement: I provided a Case of Brass that would just contain two Bars, such as are sold for half a Guinea. At one End of the Case were fixed two Feet of soft Iron, like those of an armed Loadstone, the upper Surface of which was within the Case in Contact with the Ends of the two Bars: which being parallel to each other, and their Poles in an alternate Position, the North End of one Bar will be in Contact with one of the Feet, and the South End of the other Bar will be in like manner apply'd to the Surface of the other Foot. Upon fitting a Lifter to this new kind of Armour, I found I was able to support a Weight of about 6 Pounds: The Bars are kept asunder at the Distance of about a Quarter of an Inch, by a Slip of Wood, which slides in betwixt them.

An Instrument thus constructed seems capable of answering all the Purposes for which Loadstones are used; for when the Bars are taken out of the Case, they are fit for touching Needles, or other magnetical Uses, which may require single Bars; when in the Case, the Whole together becomes an armed Magnet, able to lift a considerable Weight. And if we want to separate iron Filings from those of other Metals, the Feet and all the lower Part of the Case will take them up in great Plenty, and by drawing the Bars a little way out of the Case the Filings will fall off.

*Some further Experiments relating to the
general Phænomena of Magnetism, by the
same.*

Read Dec. 17.
1747

THE Cause of the surprizing *Phænomena* of the Loadstone has hitherto escaped our Knowledge, though diligently inquired after by Men of the Abilities. Such a Discovery is not to be made without long Experience, and a great Variety of Facts : And the Nature of the Subject is such, that the more Facts we are acquainted with, the more we find ourselves perplexed. The Conclusions we draw from some Experiments are seemingly contradicted by others : and yet these seeming Contradictions are oft-times very reconcilable upon further Experience. If what I am about to lay before the *Society* will in any-wise contribute to remove these Difficulties, I am in Hopes it will not be unacceptable; though I should not so properly explain the Nature of the Cause, as the Manner in which it acts. Many of these Experiments are not altogether new, but have not been so much attended to as they seem to deserve.

Proposition 1st.

The magnetic Matter of a Loadstone moves in a Stream from one Pole to the other internally, and is then carried back in curve Lines externally, till it arrives again at the Pole where it first entered, to be again admitted.

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Experiment

Experiment I.

If we lay a magnetical Body under a Piece of Paper or Glass that is strewed over with steel Filings or magnetical Sand, and by striking the Table put the Filings in Motion, they will readily dispose themselves in such a manner as to represent, with great Exactness, the Course of the magnetic Matter. Steel rendered magnetical is best for this Purpose, because it is of a more uniform Texture, than Loadstones, and will on that account exhibit a more regular Appearance. By this Experiment the curve Lines in which the magnetical Matter returns back to the Pole where it first enter'd are accurately expressed by the Arrangement of the Filings. The largest Curves are such as take their Rise from one Polar Surface, and are extended to the other; being larger in proportion as they arise nearer the Axis or Centre of the polar Surface. Those Curves which arise from the Sides of a magnetical Body are always interior to those which arise from the polar Surface; and are less and less in proportion to their Distance from the Ends. If any one should doubt, whether the magnetical Matter, which thus disposes the Filings, is really moving back in a Direction contrary to that with which it passes through the magnetical Body; let him try it in different Parts with a small Compass Needle, and the Fact will appear beyond Dispute.

Exp. II.

The larger the Distance is from Pole to Pole in different Magnets, the larger will these Curves be.
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This appears from examining Magnets of different Lengths. And this is the Reason why in the same Magnet the Curves are less in proportion to their greater Distance from the Ends of the Bars. For the Poles from whence these Curves arise are proportionably nearer each other.

Exp. III.

If the South Pole of one Magnet be opposed to the North of another, most of the magnetic Matter is carried directly out of one into the other: and does not return back in curve Lines till after having passed through both Magnets. It appears from the Arrangement of the Filings that the magnetic Matter proceeding from the polar Surface does not now diverge from the Axis as before, but runs more in straight Lines till it arrives at the polar Surface of the other Magnet. The Curves arising from the Sides, which before were bent towards the opposite End of the same Magnet, are many of them now bent the contrary Way towards the corresponding Sides of the other Magnet. Those which are not bent the contrary Way are such as are too remote from the opposed Pole of the other Magnet to be influenced thereby; and therefore continue their natural Course.

Exp. IV.

Whilst the Bars are in the Position of the last Experiment, if a small Loadstone be placed in the Stream running from one to the other in any Position whatsoever, the Stream will pass through the
Stone:

Stone: which, being again removed, will be found to have a Polarity exactly in the Direction of that Stream.

Exp. V.

If the North or South Poles of two Magnets be opposed to each other, the Filings will exhibit the Appearance of two Streams meeting; and the Curves of each will all be turned towards the opposite Pole of the same Magnet. The Appearance is altogether the same, whether the two North or two South Poles be opposed to each other. So that it is not to be determined from any of these Experiments at which of the Poles the magnetic Stream enters. As we have some Reason to think it enters at the North Pole, we may suppose that the Case, without Danger of Errour; provided we build nothing upon the Supposition, but what would hold good (*mutatis mutandis*) if the contrary should be true. This being supposed, when the South Poles are opposite, the two Streams coming out at them are directly contrary, whereby the magnetic Matter is accumulated, and therefore diverges so much the faster to return back to the North Poles: When the North Poles are opposed to each other, the Streams of magnetic Matter returning from the South Poles are directly contrary; and by crowding at once towards each polar Surface are accumulated betwixt them, and converge towards them so much the faster.

These five Experiments seem sufficient to establish the Truth of the Proposition; and many more might be produced to the same Purpose,

Prop. 2.

The immediate Cause, why two or more magnetical Bodies attract each other, is the Flux of one and the same Stream of magnetical Matter through them.

Exp. VI.

It appeared in the third Experiment, that when the South Pole of one Magnet was opposed to the North of another, a Stream of magnetic Matter was carried from one to the other, and did not return back to the Pole where it first entered, till after having passed through both Bars: and it is needless to observe that two Bars in this Position are in a State of Attraction. The fifth Experiment shewed, that when the two South or North Poles were opposed, there was no Stream common to both. Now it is well known, that magnetical Bodies in this Situation are so far from attracting, that they strongly repel each other. If the third Experiment be repeated, with the Magnets placed at different Distances from each other, we shall find that more of the magnetical Matter will pass from one polar Surface to the other, in proportion as the Distance betwixt is less. The Attraction is therefore greater as the Distances diminish. And at Distances where none of the magnetic Stream passes from one Magnet to the other, there is no Sign of Attraction. So that this Cause is not only coexistent with the Effect, but also proportionable thereto.

Exp.

Exp. VII.

If a Piece of soft Iron which has no fixed Magnetism is any where placed in the magnetical Stream, it will be in a State of Attraction whilst it remains in that Stream, and no longer.

Exp. VIII.

A Ball of soft Iron in Contact with the Pole of a Magnet will attract a second Ball, and that a third, and so on, till the Stream becomes too weak to produce an Attraction sufficient to support a greater Weight.

Exp. IX.

Having hung a Number of Balls to each other, by applying the first to the North Pole of a Magnet, upon presenting the South of another Magnet to one of the middle Balls; all those below it will thereby be deprived of the magnetic Stream, and instantly losing their Power of Attraction fall asunder: the Ball, to which the Magnet was applied, will be attracted by it, and all the others will still remain suspended. But if the North End of a Magnet be presented, then the Ball to which it is apply'd will also drop.

Exp. X.

In a Magnet unarmed the magnetic Stream is carried back on all Sides in curve Lines to the contrary Pole,

Pole, as was seen in *Experiment I.* but when Armour is applyed to each Pole, the magnetic Matter is thereby conducted to the Feet of the Armour; and a Lifter being thus apply'd to the Feet, the whole Stream coming out at one Pole is carried back through it to the other; by which means the Lifter is made to adhere to the Feet of the Armour with very great Force. When the Lifter is thus in Contact, the Magnet seems externally to have lost the greatest Part of its Force; though in Reality it never acted with more. If instead of the Lifter we suspend a Number of Iron Balls in Contact, they will adhere together, and hang like a Bracelet betwixt the two Feet; the returning Stream passing now through them, as before through the Lifter. Present the Pole of a Magnet, and they instantly fall asunder.

Prop. III.

The immediate Cause of magnetic Repulsion is the Conflux and Accumulation of the magnetic Matter.

It appeared in the fifth *Experiment*, that the same Poles of two different Magnets being opposed to each other, there was a Conflux and Accumulation of the magnetic Matter; and we find by Experience that all magnetical Bodies in a like Situation are in a State of Repulsion.

Exp. XI.

Two small Bars, the one hard, the other of a Spring Temper, being both magnetical Matter, were
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opposed

opposed to each other, South to South; the Filings produced the same Appearance of Repulsion, as described in the fifth *Experiment*; then the Bars being brought so near as to touch each other at the same Poles, the Repulsion was instantly changed into Attraction.

III. *A Discourse concerning the Usefulness of Thermometers in Chemical Experiments; and concerning the Principles on which the Thermometers now in Use have been constructed; together with the Description and Uses of a Metalline Thermometer, newly invented by Cromwell Mortimer M. D. Sec. R. S. &c.*

*Read May 8. 1735.
here printed with some
Alterations.*

CHEMISTRY being the most extensive Branch of Experimental Philosophy, hath furnish'd Mankind with the greatest Number of curious and useful Discoveries; for not only the Art of separating Metals from their Ores, of which Metals are form'd such Variety of useful Instruments, but likewise Cookery, which is so much concern'd about the Food of Mankind during Health, and also Pharmacy, which furnishes Medicines for the restoring Health when lost, the Art of Dyeing, and many other useful Manufactures, all owe their Improvements to this Science; many of which have been light on unexpectedly by the Operator, while he