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III. *A Paper about Magnetism, or concerning the changing and fixing the Polarity of a Piece of Iron.* By Mr. J. C.

October 14th 1694.

S I R,

HAVING but little Matter from abroad, I will here give you something of my own: Being a Breviate of some Experiments of the *Loadstone*, or rather of *Magnetism*, which I lately made.

'Tis known that a Rod of Iron held Perpendicular to the Horizon, or inclining, the lower end is its North Pole, or attracts the South end of a Magnetick Needle; and that the same end held upwards becomes a South Pole, *ſc.* attracts the North end of a Needle, and repels the South end. The South I call a mutable Pole, which may be North or South, according as you hold it. I call a Fixt Pole that which does not change however you hold it, particularly that is a fixt North Pole, which though held upwards, attracts the Needles South end, and repels the North end: And that is a fixt South Pole, which held downwards attracts the Needles North end, and repels the South end. 'Tis known that the Magnet does make ſuch fixt Poles. But to do it without the Magnet, is what I here chiefly conſider.

I. The Species of the Pole, whether North or South, may be found by paſſing the Iron Rod through Cork or Wood, and then leaving it to ſwim on Water, it will turn to its proper Pole. But this way is not nice, but in ſome caſes ſo ſlow, that you would think it to be at reſt when 'tis in motion towards its Pole. A better way to try for Inſtance a North Pole, is to hold the Iron
Perpen-

Perpendicular to the Horizon, and to try whether, being held under the North end of the Needle, it attracts it. But a yet better way is to try whether the upper end of the Rod attracts the South end of the Needle, for Attraction is more sensible than Expulsion.

2. A fixt North Pole may be made with all the ways and Rods that you can make a fixt South Pole, but not *vice versa*; for there are many cases wherein you can make a fixt North Pole, but not a fixt South Pole; and whatever way you get a fixt South Pole, 'tis weaker than a fixt North Pole made the same way. Applying a Needle to an erect Bar, beginning at the top, and so down, the Needle turns not at the middle, but nearer. Of some Rods you cannot make a fixt South primarily, yet you may consequentially; so you may make one end a North Pole, and then the other end of those Rods may without more to do become a fixt South Pole: But this does not always hold, for the one may be a fixt North Pole, the other may be a Mutable Pole.

3. Fire destroys all fixt Poles, *sc.* whether made by the Magnet, or otherways; but it increases, or rather less hinders that Magnetism which proceeds from the Earth: *Sc.* a Wire or Rod of Iron heated at one end, that end is a Mutable Pole, but more vigorous while hot than if cold, *sc.* the ignited end held downwards, will attract the said end of the Needle more vigorous, than if cold; and so if held upwards, it more attracts the North end. The vigour of Mutable Poles is more in great than little Rods, but 'tis otherways in fixt Poles.

4. Heat the end of a Rod of Iron red-hot (or heat all the Rod) and cool that ignited end Northward, it will be a (fixt) North Pole; if cooled South, it becomes a (fixt) South Pole. This say *Gilbert* and others from Experience. But I say, this holds but in some cases; *sc.* if the Rod is short, you cannot make a fixt Pole that way: Take a round Wyre whose Diameter is $\frac{1}{2}$ Inch,

Inch, and length 10 Inches, you cannot produce a fixt Pole by Ignition; but if this Wyre were longer, as suppose 30 Inches long, or never so much longer, 'tis capable of a fixt Pole by Ignition: Again, take a round Rod 30 Inches long, and one Inch diameter, this Rod is not capable of a fixt Pole at that length, though the lesser was capable at that length. And so my Experiments give me reason to think that there is no Rod or Bar of Iron ever so thick, but which if it had length enough, would be capable of a fixt Pole by bare Ignition, for of that I only speak in this Paragraph; and there is no Rod ever so short, but which if you make it sufficiently thin, is capable of a fixt Pole. So when in a Rod I could not obtain a fixt Pole at 21 Inches length in that thickness, I could by making the Rod thinner produce a fixt Pole even in the length of one Inch and less, and the Pole should be of which kind I pleased. The *terminus*, or necessary length for every thickness increases more than you would be apt to think.

5. Heat a Rod or its end red-hot, and thoroughly cool this end downwards, or towards the *Nadir*, it will have somewhat more Magnetism than if cool'd Horizontally towards the North. But the better way is to cool it a little inclining towards the North. I cannot find that Multiplicity of Ignitions does produce more Magnetism than one good Ignition; but it must be thoroughly ignited. Nor can I find by many Experiments that quenching in Water signifies to the producing or hindering Magnetism, but many Ignitions may accidentally promote it by purifying the Iron.

6. Dr. *Power* says, That if we hold a Rod Northward, and hammer in that position the North end, that will become a North Pole, *i. e.* a fixt North Pole; contrarily if you hammer the South end. Now this is true only in some cases, *sc.* it holds in Rods only of a certain length.

length: Sc. I say here again, as before of Ignitions, that of round Bars of the same Diameter there is required a certain length, under which a fixt Pole can't be produced by hammering, but of any length more than that certain length, you may make it; and then if you take a Bar shorter than that length of which you can't make a fixt Pole, while you keep that Diameter; if you take a Rod of the same length but less Diameter, you may by blows produce a fixt Pole: Or if you only beat that thicker Bar thinner, you may produce a fixt Pole, tho' the Rod is never so short, provided you beat it thin enough.

7. What is said of Hammering, is to be understood of Filing, Grinding, Drilling, Sawing: yea, a hard Rubbing, yea, a soft Rubbing, provided 'tis long, will produce fixt Poles; the more heavy the blows are, *cæteris paribus*, the Magnetism is more: I say, *cæteris paribus*, as when the blows be not so heavy in either case as to flat, for flattening the Iron produces more Magnetism, though other things don't vary. A few hard blows will produce as much Magnetism as many, as to sense, as if you give never so many blows; yet a soft blow, may produce but little Magnetism. The utmost Magnetism that I could produce in ordinary Rods this way, did not exceed that which an ordinary Loadstone would have infused.

8. Beating many Rods Northward, whose lengths I knew sufficient, I never failed of producing a fixt North Pole; but hammering the same or like Rods Southward, I found that I could not produce a fixt South Pole, only a mutable Pole; nay, hammering one full South, I produced a fixed North Pole: Then I thought the reason might be, that the hammered South end on the Anvil was a little lower than the end which I held in my hand. Then I held the end higher, and South upward, and so

to hammering it South upwards, I never failed producing fixt South Poles in proper Rods.

9. Old Drills and Punches are fixt North Poles, because almost constantly used downwards, but new Drills are either Mutable Poles, or weak North Poles; when I say a new Drill, I don't mean one made on the spot, for that is probably a North Pole, because quencht downwards in Water; but then such Polarity made by bare Ignition is a weak Pole, and soon decays, and turns to a Mutable Pole: But I mean a Drill, which though never or little used, yet has been made some Days or Weeks; Drill with this Southward Horizontally, and 'tis a chance if you produce a fixt South Pole, but much less if you Drill South downwards, but if you Drill South upwards, you may make it a fixt South Pole.

10. The stronger the Polarity is, the longer it will last; a weak fixt Pole may degenerate into a Mutable Pole in a days time; yea, I have known it in a few Minutes, while exposed to the Air, and held in a position contrary to its Pole: On the contrary we find Needles toucht with good Loadstones hold that Vertue a great while, if kept from Air, and in a Meridian site.

11. The Loadstone it self will not make a fixt Pole of any Iron, only it must have a proper length if 'tis thick; or if 'tis short, it must have a sufficient thinness: So, ordinary or weak Loadstones cannot fix a Pole in a thick short Key, which yet they will do in a little Key. So in a short thick Iron tapering, a Loadstone may fix a Pole in the little end, when it cannot in the great end.

12. When Ignition, Hammering, or a Loadstone cannot make fixt Poles, it must not be thought that it can do absolutely nothing on such Rods, for even then it may be found that there's an Effect of Magnetism in them discernable enough otherways, though not enough to make fixt Poles.

13. When you have the due length for making a fixt Pole, you will find the making one a fixt North, will consequently render the other a fixt South Pole; but if keeping the same Diameter of this Rod, you increase its length enough, the making one end a fixt North Pole, will not necessarily make the other a fixt South Pole, but leave it a Mutable Pole. So if you by a like Primary Operation make the second end a fixt Pole, the first end will lose its fixity, and become mutable. I say, there's a certain length suited to every thickness of Iron, to leave one end mutable, while the other is fixt, and the thicker the Iron is, the greater is this length.

14. If you further increase the length of the same Rod, you will attain such length, that the oftner you have fixed a Pole on one end, and then go to fix the other end, the fixity of the first will not be destroyed, and that end become mutable as before, but the fixity of the first end will remain, and so you make both ends two fixt North Poles, or two fixt South Poles. I say, the shortest length (for there's no *terminus* of the greatest length) for this is more in thick than in thin Iron.

15. The aforeſaid lengths are leſs, according to the ſtrength of Magnetiſm, ſc. Ignition requires a greater length than when a Rod is actuated by a Loadſtone; and a Rod touch'd with a ſtrong Loadſtone requires leſs length than one touch'd with a weak one.

I have ſome Years ſince read *Kircher*, *Gilbert*, and *Dr. Power*, who mention nothing of this, nor any other Author as far as I remember; I am ſure it was new to me. I hear *Dr. Plot* has a Manuscript of *Monſieur Chamar's* Magnetical Experiments; alſo there's a *French* Author publiſht not many Years ſince on this Subject: Alſo *Dr. Wallis* thinks the *Royal Society* has made Experiments of Magnetiſm. I have ſeen neither of theſe, perhaps they have done this Subject to much better purpoſe than your
 &c. IV. An