A Letter of Mr. De la Hire *of the Royal Academy of the Sciences at Paris, concerning a new ſort of Magnetical Compaſs, with ſeveral curious Magnetical Experiments.*

YOU know Sr. that there is nothing which creates ſo much trouble in long Voiages on the Sea, as the Variation of the Magnetical Needle, both becauſe this Variation is different in differing places, and becauſe in the ſame place it changes conſiderably in proceſs of time. It ſeems that if we had exact Obſervations of the irregularities of this Variation, made all over the Earth, and at a conſiderable interval of time, one might diſcover ſome Period of this motion, and eſtabliſh a Syſtem which might be of great uſe in Navigation. But ſeeing our oldeſt Obſervations were made but about a hundred Years ſince, and in ſome particular places only, they only ſerve to let us know, that if there be a regular Motion, it muſt needs be very ſlow: So that we can conclude nothing certain for the time to come from all that has been hitherto Obſerved. This is not becauſe of any difficulty that there is in aſcertaining this Variation by Obſervation, ſince it is found to Change but few Minutes in a Year; but too much reliance muſt not be upon the Obſervations of Pilotes, by reaſon of the groſs Errors which it is not eaſy for them to prevent. For it often happens that near the place where the Compaſs is, there is much Iron, which draws the Needle, and cauſes it to ſhew a point on the Horizon much different from what it would, were it farther from the Iron; which makes it be thought that there is a conſiderable Variation where perhaps there is none at

at all. And it may ſo happen that in the ſame place where the Year before an Obſervation was made, if in the next, the Iron Inſtruments be found otherwiſe placed than they were the time before, either in the ſame Ship or another, the Needle will ſhew a Variation much differing from that found the firſt time. And this ſort of Caution not being Obſerved at Sea may be cauſe of very great Errours in the Obſervations of the Needles Variation tho' not affecting the Courſe of the Veſſel. For the Needle being drawn after a certain manner will conſtantly obſerve the ſame ſituation in reſpect of the North, provided the Iron round about it be not ſtirred: And you ſhall not fail to ſteer true upon any point of the Compaſs, if this falſe Variation be obſerved after the uſual Manner by the Amplitudes of the Sun. We cannot therefore hope to be ſecure of any thing from the Obſervations we have at preſent, and eſpecially from thoſe made at Sea, which are the moſt conſiderable. This put me upon finding out ſome means independent from Obſervations to diſcover the Variation at Sea; but having conſidered that ſeveral learned Men of this age had propoſed divers ways of making Magnetical Needles, which ſhould not be ſubject to Variation, and that all theſe propoſitions had had no effect; I judged that after all that they had done by means of the Loadſtone, it was not to be hoped to draw any farther advantage from it; ſince the Stone itſelf, as far as might be gueſſed from the Experiments hitherto made, was ſubject to the ſame Variation:

I had quite given over this Enquiry, when there accidentally fell into my hands a *Terrella* or Spherical Loadſtone, of three Inches Diameter; with which being minded to make ſome Experiments, with a little Needle whoſe foot might eaſily be placed upon the Stone, I ſoon Obſerved that which hath been already noted by ſeveral, *viz.* that this Globe of Magnet cauſed the Needle to have the ſame changes which are found in the Compaſs in diffe-

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rent parts of the World, as well in reſpect of the direction towards the two Poles, as of the Inclination towards that which is next it: And upon tryal I ſatisfied myſelf that it was not poſſible to find the Point where the Neeple would ſtand indifferently in any poſition, (which Point would have exactly ſhewed me the Pole of the Stone) but that the Needle however placed always directed itſelf ſome one way. I determined by this means, as well as I could, the Point called the South Pole; but I was much ſurprized to find it 18 Degrees diſtant from a Croſs deep engraven on the Stone, which according to all appearance had heretofore been the Pole of this Stone, as it had been Obſerved by him that Cut it. This change of the Poles of this Stone having revived my former thoughts concerning the Variation of the Needle, I believed that if it were true that the Poles of the Magnetical Vertue changed in the Loadſtone, as we ſee they change in the Earth, one might derive great advantages therefrom as to the Variations of the Magnetical Needle. For if this change of theſe Poles in the Load-ſtone were certain, and that it was Analogous to the change of the Poles of the Magnetique Vertue in the Earth, it is not to be doubted but a *Terrella*, being ſuſpended at liberty, would remain immoveable, and that one point thereof would regard the Pole of the World, which might be called the true Pole of the ſtone, whilſt the Poles of its Vertue would paſs ſucceſſively from one part to another, after the ſame manner as they change in the Earth.

After having well conſidered this Hypotheſis, and having cleared up ſome doubts which I had, concerning the Poſition of the Stone at the time when its pole had formerly been determined; I concluded that this former Pole was diſtant from the point I call the true Pole, thirteen Degrees towards the Eaſt, in the place where it had been marked (and which is unknown to me) ſince that at this time in this Country the Needle varies about five Degrees Weſtward.

Upon

Upon this Hypotheſis, which I know not that any one elſe has yet thought upon, I have invented a new ſort of Needle for the Compaſs, which may have the ſame alterations as a Sphærical Load-ſtone, and at the ſame time the ſame conveniencies as the ordinary Needle hath.

I cauſed a Ring of three Inches diameter to be made of Steel Wire; from which there went three Radii of very fine Braſs-wire meeting at the Center in a Cap perfectly like that of an ordinary Compaſs, that ſo this Circle might reſt on a Pin in its Center, and be at full liberty to turn round, its Center being fixt. This done I gave the Magnetical touch to this Steel Ring, by applying indifferently to a Point thereof, one of the Poles of a ſtrong Load-ſtone, and the other Pole of the Stone to the oppoſite Point, to give the greater Vertue to the Ring. Then I obſerved that the Ring was ſtrongly Magnetical, and that the Point called the South Pole did readily turn itſelf towards the North, and after ſeveral Vibrations ſtopped there; and that it had alſo the ſame inclination towards the Pole which is found in Needles after they have been touched: Laſtly I fixed upon the Ring a ſmall *Fleur de Lis* of Braſs, in the Point which exactly reſpected the North, the Ring being firſt well ſettled.

If the Poles of the Magnetick Vertue change in the Load-ſtone after the ſame manner as they do on the Earth; it ſeems likely that the ſame thing ſhould happen to this Ring, and that one Point thereof ſhould alwais exactly reſpect the North. But to informe my ſelf if a Steel Ring had the ſame effects as a *Terrella*, I made the following Experiment. Having touched a Steel Ring, and having laid it on a Paper, I ſtrewed the filings of Steel upon it; and then gently ſhaking the Paper, I ſaw that the direction of the Magnetical matter paſſed directly croſs the Ring from one Pole to the other, and that there were two *Vortices* on the ſides, as it is obſerved in the Sphærical Magnet; which ſeems very ſurpriſing: For

according to the ordinary Hypotheſis of the Magnet, the Magnetical Vertue paſſing more eaſily in the Steel than in the Air, ſhould run on both ſides of the Pole round the Ring, and only form a Pole oppoſite to the firſt. But I was further confirmed in this Opinion by applying a flat and pointed piece of Iron, like the blade of a Knife, to a Load-ſtone, ſo as the Point of the Iron reached beyond the Stone; and having afterwards preſented this point to the Magnetical Ring, I obſerved that different Points of this Ring did apply to the Point of the Iron, according as the ſeveral parts thereof had been applied to the Stone: which happens not in the Magnetical Needle, for that always preſents one of its ends to the Point of the Iron, being not diſpoſed, by reaſon of its length, to receive the Magnetical matter in all the parts thereof analogous to thoſe of the Sone. It muſt only be noted that in an irregular Stone the Magnetical Vertue appears ſtronger towards the Angles than in the other parts, which may cauſe ſome irregularity in this Experiment, if it be tried with a Stone that is very uneven.

Theſe Experiments gave me the Curioſity of making another, by touching two Semi-circles of Steel. Having joyned the two ends touched by the ſame Poles, I obſerved by the Steel-duſt the ſame effect as in the Ring. But having joyned the ends differently touched; I found that immediately the two half-rings run together and ſtuck to each other; and by the Steel-duſt ſtrowed on Paper I obſerved, that there were four *Vortices*, one in the middle of each ſemi-circle, and one at each of the places where they were joyned, ond that the two latter were leſs than the others and much ſtronger. I ſaw likewiſe that there were four Poles, each of which was within a *Vortex*, and that each retained in its ſemi-circle the Vertue of the ends of the half Rings.

I would trie, after having touched a Steel-Wire that was ſtreight, to make a Ring thereof; but I found that it had quite

quite loſt its Vertue: which cannot be attributed to the junction of the Poles, ſince they ought to ſtick together, according to the other Experiments which have been made; but only to this that hath been already noted, that when a Magnetical *Virgula* is a little bent, it looſes its Virtue, which cannot happen but from the alteration of the Pores of the Steel.

I farther remarked that a Ring of Steel having been touched does for a long time retain its Vertue although it be put in a poſition contrary to its Poles. And this Experiment is confirmed by another much more conſiderable: Which is, that a Ring of Steel having been touched with a ſtrong Load-ſtone, cannot without difficulty receive a contrary touch from a Magnet leſs ſtrong than the firſt; but that in time by little and little it reſumes its former Vertue, much as we ſee Magnets do, which being applyed to another Stone, by the Poles of the ſame denomination, looſe their firſt Vertue and take a contrary; which they afterwards looſe by degrees, to reaſſume their firſt.

After I had preſented this new Syſteme of the Magnet to the Academy, there were made ſome Experiments upon a *Terrella* of Much the ſame diameter with mine, but whoſe Poles were not diametrically oppoſite; and upon a half-Globe very much bigger than the *Terrella*. We could find in them no conſiderable difference or alteration of Poles: Yet becauſe of ſome circumſtances, the Company thought fit that ſome Experiments ſhould be made with this ſort of Compaſs.

If ſome of theſe Compaſſes were carried into very remote parts, where it is known that the Magnetical Needle has a great Variation; one might be certain in little time whether this Hypotheſis holds or no, and whether we may expect from it thoſe advantages, which I have concluded from the ſuppoſed immobility of a *Terrella* hung at liberty.

It remains only to explain after what manner theſe circular Needles may be touched a new, when it is perceived that they have loſt their firſt Vigour. According to this Hypotheſis, it is evident that if the Circle be not touched in the point that anſwers to that of the Stone, with regard to its Variation, the little *Fleur de Lis* which marked the true North, may decline a little from it; and the difficulty of finding the correſponding points on the Ring and the Stone, would cauſe that the touch of the Circle could not be refreſhed, without taking great care and firſt obſerving the Meridian line. But to avoid all theſe difficulties, you need only apply the Poles of the Stone to the Ring; and the Ring, which is ſuſpended upon its pivot, will turn ſo as the Point anſwering to the Pole of the Vertue of the Stone which is applyed to it, will come as near to it as poſſible: In ſo much that without touching the one or the other, the Ring will not fail to receive very much force. The ſame may be done at the oppoſite Pole.

I doubt not but you are curious enough to ſee if the Poles do change in the *Terrella*, when you ſhall meet with one fit for this Experiment. There might ſeveral other things be noted upon this Subject, and it were to be wiſhed that ſome other particular obſervations might be made as opportunity ſhall offer; but unleſs curioſities of this nature fall into the hands of ſuch as have a great love for the advancement of the Sciences, it is not to be hoped that we ſhall have any certain information in a matter ſo nice, *&c.*

Paris
April. 26. 1687.

This Letter having been produced and Read before the Royal Society; it was Ordered that the *Terrella*, which has been in their Repoſitory theſe 25 Years, the

the gift of their Royal founder King *Charles* the Second, ſhould be examined, to ſee if there be any ſenſible alteration in the Poles thereof: And upon tryal it was found that the Points which are marked thereon with croſſes, were as near as could be diſcerned the true Poles of the Stone; notwithſtanding that the Variation has changed at *London* full 4 Degrees ſince this *Terella* has been in the Society's Cuſtody; and perhaps many more ſince it was marked: and had there been a change in the Poles of the Load-ſtone analogous thereto, it muſt needs have been perceived in this, whoſe Diameter is about 4 ½ Inches. However to put this matter paſt diſpute, care was taken to find out exactly and mark the Poles of the Society's great Load-ſtone, the Sphere of whoſe activity is above 9 Foot Radius, and whoſe Poles are 13 Inches aſunder, whereby if this Tranſlation of the Poles be real, it cannot fail of being made very ſenſible in future times. As to the ſuppoſition that the Points in which the Iron hath received the Magnetical Vertue may change place, after the ſame manner as the Poles of the Earth's Magnetiſm are obſerved to do; tho' it was lookt upon as an ingenious hint and worth proſecution, yet ſome of the Company, well ſkill'd in Magneticks were of opinion, rather that ſuch a Circular Needle would librate on its Center, ſo as to reſpect the Magnetical Meridian with the Points that had at firſt received the touch, than that the Ring remaining immoveable, the derective Vertue ſhould be transferred therein from place to place, either by length of time, or by tranſporting this Compaſs into thoſe parts where the Variation of the Needle is conſiderably different.

A Re-