

XXXIV. *On some new Methods of suspending Magnetical Needles.* By John Ingen Houfz, *Body Physician to their Imperial Majesties; and F. R. S.*

Read June 17, 1779.

THE very great utility which navigation derives from the use of compasses, has been the principal reason, that so much labour has been bestowed by many ingenious men in searching the best method of suspending magnetical needles, and that some Academies of Sciences have proposed considerable premiums to be given to him who should succeed the best in this important object.

It has been, and is still, a general complaint, that such needles as were by their size and figure susceptible of the greatest magnetical power, and which were executed with the greatest exactness, and perfectly balanced, were, for this very reason of their superior accuracy, so easily put in motion, that the slightest shaking of the floor, occasioned by the observers walking in the room, communicates to them such a great quivering motion as to drag them out of their direction, and to render a considerable
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time requisite before they are again fixed in the true magnetical meridian.

Since the late Dr. KNIGHT has improved so greatly the method of communicating a considerable magnetical force to steel bars, needles have been impregnated with a much greater and more permanent polarity than it was possible to give them before, and the construction itself of compasses has been considerably improved. But the subject seems not yet to be exhausted.

The degree of magnetical power or polarity to be communicated to steel well hardened seems to depend in some respect on the proportion which the surface of the piece of steel to be impregnated bears to its bulk; so that a thin lamella of steel, weighing for instance ten grains, will acquire more magnetical force than a little lump of steel of the same weight. Thus a small magnet, composed of a great many thin lamina of steel pressed together, may be made so strong as to support 150 times its own weight, and even more, which has never yet been done by a compound heavy magnet.

If the too great quivering and horizontal motion, or the too great restlessness of a strong magnetical needle, is in some way or other counteracted by the methods hitherto adopted, the needle is in some danger of stopping near the true magnetical meridian, without always pointing

pointing directly in it; because near this very place the power of direction of the needle may be so weak as not to overcome the resistance, which was opposed to its free horizontal circular motion.

I thought, in the course of last year, that a great part of the above mentioned difficulty might be taken away by different methods, some of which are the following.

EXP. I. I placed an ordinary magnetical needle, supported upon its point, in a china basin, and poured water into it, so as to cover the whole needle. The needle lost a great deal of its restlessness, was influenced by the approach of a magnet at a considerable distance, and seemed to point as well as before to the magnetical meridian, though with a slower motion.

EXP. II. I took a strong flat magnetical needle, having in its center a round hole, but no cap. I fixed to this needle as much cork as was necessary to make it just swim upon the water in a basin. I fixed a smooth brass pin in a vertical position, so that it passed through the hole in the center of the needle, to prevent its swimming to the sides of the basin. This did tolerably well: the needle moved to the magnetical meridian with a slow motion.

EXP. III. I then took the needle used in the first experiment, and fixed upon it as much cork as was requisite:
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just to make it sink. I placed a point under it, so that the needle with the cork was kept a little below the surface of the water, bearing upon the point with a very inconsiderable weight. This answered nearly as in EXP. II.

EXP. IV. I fixed to the center of a small, but strong, magnetical needle a silver wire; to the other extremity of this wire I fixed a small steel-working needle, very much hardened. I stuck the point of this working needle to the lower extremity of a steel magnet, placed in a vertical position and highly polished. This whole apparatus was placed in a glass cylindrical vessel, filled with water so far as to cover the point of the working needle. The horizontal magnetical needle, thus suspended, was remarkably quick in directing itself into the magnetical meridian, and was very easily displaced out of its direction by the approach of a magnet at a considerable distance.

The greatest difficulty I found in this contrivance was, that a little jerk shook the point of the working needle from the vertical magnet; and that a heavy magnet could not be suspended from the point of a working needle, but required a tolerably good magnet rounded at its extremity, where it was suspended from the vertical magnet, or a thick piece of iron rounded in the same manner, by which means, however, the horizontal
magnet

magnet did not move so freely. The first difficulty could be easily diminished by letting the working needle pass through a small and smooth hole in a glass or metallic plate, to controul its vibrating motion, and by adapting to it a shoulder, by which it should stop upon the glass or metallic plate, and from which it should be taken up again, by sliding the vertical magnet a little down so as to touch the point of the working needle, and to lift it up again into its former place. The second difficulty could, I think, also be in a great measure obviated by employing, instead of a common magnetical needle, a thin steel tube (of which I will speak by and by) which is only a little specifically heavier than an equal bulk of the liquid. By this means a small vertical magnet could be made to support a large one, even of a considerable absolute weight, of which weight, however, the vertical magnet should support almost nothing, it being counter-balanced by the fluid in which it is immersed.

In the experiment, as I had made it, I could not perceive, that the horizontal magnetical needle was influenced by the vertical magnet, which would probably be the case if the vertical one was much out of the vertical line, and too near the horizontal needle.

EXP. V. I adapted to a flat strong magnetical needle two caps, turned one against another, so that the needle

could be supported on either of the caps, and turned with either surface upwards. I fixed on one of the flat surfaces, on each side of the center, a thin glass tube, hermetically sealed, of such a size, as made the whole together dip in the water so deep that only a small part of the glass tubes remained above the surface of the water. I then depressed the needle entirely under the surface of the water by thrusting a metallic point in the cap which was uppermost, and fixing this point to the cover of the basin: thus the needle, kept under water, bore against the point only with that small degree of pressure which the very inconsiderable difference of specific gravity, which it had above an equal bulk of the water, could give it, which did not amount to above a few grains of weight. Thus this needle, losing nothing of its polarity, lost very near the whole of the resistance of its weight, and at the same time that quivering motion and restlessness, which it had in the air, moving smoothly in a medium, which could only obstruct its too great vibrations (almost in the same way as astronomers stop the vibrations of their plumb line by hanging the weight in water or oil) without obstructing (but retarding only) its tendency to the magnetic meridian, liquids pressing equally on all sides.

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To prevent this needle from being shook off the point, and wandering about in the bafon, I placed also a metallic point underneath, upon which the under cap must bear if the needle should by any cause descend from the upper point, or if I should chuse to make the whole sink by increasing its weight.

Having now found, by experience, that a strong magnetical needle did point to the magnetical meridian near as well under water as in the open air, and that by the resistance of the medium much of its too great verfatility was taken away; I wanted to try, what degree of magnetism could be given to a thin steel cylindrical tube, as a needle made in this shape could be as light as required without being incumbered with cork or glass tubes; but finding no such tubes ready made, I tried one made of tin and found it susceptible of a much greater magnetic virtue than I expected, considering that the iron plates of which it is made are neither sufficiently hardened for this purpose, nor approach enough to the nature of steel; besides that, being covered with a pewter coating, they cannot be exposed to the bare friction of a steel magnet.

This experiment, however, afforded me a certain proof, that a magnetic needle, made of a thin steel tube,

would be susceptible of a strong polarity, so as to serve for the purpose here intended.

But as the two agate caps, if fixed in the middle of the substance of the tube, would interrupt some part of the continuation of the steel, and thus lessen the magnetic power, the points of suspension would be better foldered or fixed upon the surface of the tube itself, and the agate caps fixed upon the support underneath and above the tube; so that such a needle should be the reverse (in respect to the suspension) of the common needles. Another advantage would be derived from fixing the points of suspension upon the needle itself, *viz.* that by the motion of the fluid in which it swims, it would be less apt to acquire a too strong waving or undulating motion.

If it should be found difficult to make very thin steel tubes properly hardened, a piece of steel could be scooped out so as to constitute the half of a tube; the other half could be made of another similar piece, or perhaps better of thin brass, or any other metal, and they might be foldered together.

It would, perhaps, answer the same purpose if a steel magnet was shut up in a thin tube of glass or some metal.

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I should think, that there could be no great difficulty to adapt to these kind of needles a thin glass, metallic, or enamelled plate, serving instead of the card in the common nautical compasses, and to make use of them in azimuthal compasses.

A card, if it is not required to be stuck upon the needle, might be fixed to the bottom of the glass basin destined for this apparatus.

Common water would be, perhaps, the best medium for these different contrivances, if steel was not so easily rusted by it, if the needle was covered with some varnish or metal unalterable in water, and if in cold weather it was not so apt to freeze; and therefore, I think, some of the thinnest expressed oils would answer the purpose better. Linseed oil, when it has subsided, is very clear and transparent, and is not subject to freeze, at least in the common cold of our climates; besides, it increases the magnetical power of steel, as Dr. KNIGHT found. If it thickens by time, it may be changed.

The glass basin containing such a compass should be kept full of the liquid to the cover, to obstruct undulating motions.

The plate joined to this paper is not made to serve as a model of a complete apparatus, as the drawing was made
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from fancy. It is destined only to convey an idea of the invention. I make no doubt but that ingenious artists would soon greatly improve this rough sketch, if the contrivance should be found by experience to answer at sea.



