

**A treatise of artificial magnets ; in which is shewn an easy and expeditious method of making them, superior to the best natural ones, and also, a way of improving the natural ones, and of changing or converting their poles : Directions are likewise given for making the mariner's needles. In the best form, and for touching them most advantageously, &c; / by J. Michell.**

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Michell, John, 1724?-1793.

### **Publication/Creation**

Cambridge : Printed by J. Bentham ..., and sold by W. & J. Mount & T. Page ..., J. & P. Knapton ..., C. Bathurst ..., London; W. Thurlbourn ..., J. Merrill in Cambridge; J. Hildyard at York; and J. Fletcher at Oxford, 1750.

### **Persistent URL**

<https://wellcomecollection.org/works/z45smb9v>

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A  
T R E A T I S E  
O F

*Artificial Magnets;*

In which is shewn  
An easy and expeditious METHOD  
of making them,  
Superior to the best *Natural* Ones:

AND ALSO,  
A Way of improving the *Natural* Ones,  
and of changing or converting their POLES.

Directions are likewise given  
For making the *Mariner's Needles* in the best Form,  
and for touching them most advantageously, &c.

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By J. MICHELL, B.A.  
Fellow of *Queen's College, Cambridge.*

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C A M B R I D G E :

Printed by J. BENTHAM, Printer to the UNIVERSITY;  
and Sold by W. & J. MOUNT & T. PAGE on Tower-Hill,  
J. & P. KNAPTON in Ludgate-street, C. BATHURST in Fleet street,  
*London*; W. THURLBOURN, and J. MERRILL, in *Cambridge*;  
J. HILDYARD at *York*, and J. FLETCHER at *Oxford*.

M.DCC.L.

(Pr. 1s.)

magnets 1816

26

# THE ATLAS

OF THE

AMERICAN  
REPUBLICS  
AND  
THEIR  
RELATIONS  
TO THE  
EUROPEAN  
NATIONS

BY  
J. M. SMITH, ESQ.  
OF THE  
OFFICE OF THE  
SECRETARY OF THE  
NAVY  
AND  
OF THE  
OFFICE OF THE  
TREASURY

NEW YORK:  
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1845



A TREATISE of  
*Artificial Magnets.*

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INTRODUCTION.

THE design of the following pages is to communicate to the Publick a very easy and expeditious way of making Artificial Magnets.

The Advantage, that must arise to Mankind in general, but particularly to Seamen, from having a Method of procuring † Magnets much superior to the best natural ones at a very trifling expence, will sufficiently justify the publication of this treatise, with respect to the *Matter* contained in it: and as to the *Manner*

† Perhaps some may imagine, that though the Artificial Magnets may be superior to the others in Strength, &c. yet possibly there may be some difference in the Direction of such Needles as are touch'd by them, and of those touch'd by Natural Magnets; but different Magnets, of any kind whatsoever, never make the least difference in the Needles they touch, except in the degree of Strength which they communicate; this is a fact well known to all who are acquainted with the nature of Magnetism.



and *Form* of it ; these I must leave entirely to the candour and courtesy of the Reader.

I proposed at first to publish, with this Method of making Magnets, a Theory also of Magnetism, which I endeavoured to establish by Experiments ; to which I added others of a miscellaneous nature, such as appeared to me most useful or entertaining, amongst those I had either made myself, or collected from the labours of others ; but finding that this would swell these sheets to too great a bulk, I chose to defer that part till some other opportunity ; especially when I considered, that any Philosophical Enquiries into the Laws and Nature of Magnetism, would be of very little use or entertainment to many of the Artificers and Seamen, for whom principally I intended this part.

I have endeavoured every where to make myself as intelligible as possible, and have omitted nothing, that appeared likely to prevent any mistakes. This may make some things perhaps seem tedious, or unnecessarily repeated ; but if any person thinks so, I must beg him to consider, that all people are not equally ready at comprehending descriptions of things, they were not before acquainted with ; and that therefore he ought to bear a little with what to  
him



him may seem unnecessary, for the sake of others less acute and ingenious than himself.

The Reader will meet with some few directions for making Needles in the most advantageous manner ; for touching them properly ; &c. together with some uses of Magnets either not commonly known, or at least not much attended to by the generality.

In the method of making Artificial Magnets, another Magnet is made use of, in order to obtain some degree of power to begin with ; but that no one may be at a loss in case he should want to make them, where no other is to be had, there is a method proposed towards the end, of obtaining Magnetism by means of three Iron bars.

As it is necessary, that all single unarm'd bars, intended to be made Magnets, should have a sufficient length in proportion to their weight ; for otherwise they will not attain to near so much perfection ; there is therefore subjoined a table of such lengths as are proper for bars of several different sizes. Besides the plain strait bars, which are the most proper for common uses, there are a few other forms proposed, such as seem'd most likely to be farther convenient and useful upon different occasions. To the whole are added directions for improv-



ing the *natural* Magnets, changing, or converting their Poles, and for making both single and compound armed *artificial* ones in imitation of them.

It may not be amiss to mention some of the Advantages, that the Artificial Magnets have over the Natural ones, and to say a little in favour of the Method here offer'd to the Publick for making them, which is probably capable of bringing them to the greatest perfection, the nature of the materials, they are made of, will admit.

The Advantages then of Artificial Magnets are,

*First*, That they may be had at very little more expence and trouble, than the prime cost of the Steel they are made of, and the labour of forging them into bars of a proper size and shape; whereas the Natural Magnets (such as are good at least,) are very expensive; and if armed, there must be a good deal of labour bestowed on them in grinding the Poles, fitting on their Armour, &c.

*Secondly*, They may be had plentifully enough to supply every body; but Natural Magnets, that are good for any thing, cannot be procured at all, except in small quantities.

*Thirdly*,



*Thirdly*, They are greatly superior to the Natural Magnets in Strength, and perhaps better able to communicate the Magnetic Virtue in proportion to their Strength: very few of the Natural Magnets are able to touch well a Needle that is hard, unless it be very small; but good Artificial ones will do it very easily; and on account of this \* inability of the generality of Natural Magnets to touch large needles when hard, it has been the usual practice to reduce almost all Mariner's needles to a spring temper, that they might be able to receive a sufficient Strength from their touch, which otherwise they would not do.

Perhaps some may be apt to imagine, because the Natural Magnets, which are armed, (as most of them are,) lift sometimes a great deal more than single Artificial Magnets, that therefore they are better; but this will be easily disproved by experience; the reason, why they shew so much to advantage, is because they will lift vastly more in proportion by both Poles, than by one; and this also the Artificial

\* It is this weakness of the Natural Magnets, that has led several into the error, that spring-temper'd Steel will receive the greatest Power; whereas it only receives the Magnetic Virtue with *more ease*, but will not *retain* so much of it.



compound Magnets will do ; and they will besides lift much more than the Natural ones of the same Size. The following instance may serve to shew the difference between the Artificial (single) Magnets and the Natural ones : I have a Natural Magnet, which weighs six Ounces and half with its armour, and which is able to lift by both Poles ten Ounces, that will not touch a piece of Steel so well, as a good Artificial single one weighing only an eighth or tenth part of an Ounce.

A good Artificial Magnet of about two Ounces weight, six Inches long, will touch as large and as hard a Needle, as *most* of the best Natural Magnets in use, and perhaps as *any*.

*Fourthly*, The Ease, with which Artificial Magnets are restored to their former Strength, in case they are at any time damaged, gives them a great Advantage over the Natural ones ; which are nearly, if not altogether as liable to be impaired, as the former, and cannot be restored but by the assistance of them, or by Natural ones greatly superior to themselves.

*Fifthly*, In the Artificial Magnets we can have several Poles ; as for instance, in a long bar we can have a North Pole at each end, and a South Pole in the middle, or two or three South Poles, and as many North Poles, alter-



alternately, &c. this is what cannot be had in the Natural Magnets, but by chance, and in a small degree; and though this may be no great advantage for the common purposes of Magnets, yet it may be of use to those, who would try Experiments.

*Sixthly*, The Artificial Magnets have many Advantages on the account of their being made in any Form. The Natural Magnets are much too short, in proportion to their bulk, and consequently cannot attain to that perfection, which they otherwise might do: some of them are so very deficient in length, that probably, if they were slit into a hundred pieces, of the whole length of the stone, and properly made magnetical, they would make a hundred Magnets, each better than the whole stone was before.

Another Advantage of Shape is, that the two Poles of an Artificial Magnet, of any Size, may be brought as near each other, as any one pleases, and yet the Magnet have a sufficient length in proportion to its bulk; as in the Annular and Horse-shoe Magnets hereafter described.

The Convenience, with which the Artificial Magnets (on account of their being long and slender in comparison of the others,) may be applied



applied in the manner of the *double Touch* (hereafter described) is another Advantage arising from their Shape, and a great Advantage indeed it is ; since by this means half an Ounce of Artificial Magnets may easily be made to touch a much larger bar, than the best Natural Magnet in the known world : the Natural Magnets too indeed may be applied after the manner of the *double Touch*, and with considerable Advantage, but vastly less however than the others ; with which it is as practicable to communicate the Magnetic Virtue to a bar of Steel of a Ton weight, as to one of an Ounce, and that with a small quantity of them, perhaps two hundred weight, or less ; whereas it would be impossible to do it with less than some thousand Tons of Natural Magnets, and those not less than some hundred Tons weight each.

This may suffice to convince every impartial Person of the great Advantage of Artificial Magnets.

It may perhaps be expected, that, as Dr. *Knight*, (who first brought the Artificial Magnets to their present known perfection,) and perhaps some others have made Artificial Magnets, as well as myself, something should be said of their Method compared with what is here offer'd to the Publick : Whether theirs is  
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the same as this, I know not, though I have some reason to think it is; but whether it be so or not, it is highly probable, that this is equal to theirs, or any other that is already, or may be hereafter found out; this ought not however to deter any one from attempting farther improvements; for how probable soever it may seem at present, that the method here proposed is as good, as any can be, it is nevertheless but *probable*.

I have compared several Magnets, made after the Method here proposed, with those I have seen of Dr. *Knight's*, and have found some of them greatly superior to what those of his were, when I saw them; and considerably superior to what his were said to have been at first, when they came out of his hands. I have had, amongst those I have made, three or four, the heaviest of them weighing about an Ounce and three quarters, that have lifted, when fresh made, from eighteen to twenty Ounces each, and have all continued to lift better than seventeen: these indeed were all pointed at the lifting end, which will make them lift perhaps an Ounce or some such matter more, than they would otherwise do; but they were also considerably lighter, than those, with which they were compared, which were



five Inches and half long, and were reckon'd to lift at first only fifteen or sixteen Ounces, but when I saw them, they would not lift near so much as that, probably, for want of proper precaution in keeping them. †

I have heard of Magnets, of the size of those just mention'd, that have lifted seven or eight and twenty Ounces: this, if true, must have been owing probably to some difference in the hardening the Steel, or in the Steel itself; or, which is most likely, to the difference of form, or some other circumstances in the Iron lifted; for on trying lately one of the three or four Magnets mention'd above, (which was no better than the rest, but as near as might be of the same goodness with them,) I found it, just after it was retouched, to lift an Iron Poker, weighing two and twenty Ounces, with great ease; and it continued several days after that

† From what has been here said, I do not mean to infer the superiority of this Method above the Doctor's, but only an equality with his, (which most probably is the same with this;) the difference here mention'd being owing, in all likelihood, to the want of proper care in the *hardening* of the Steel bars, that his were made of; which is a most material Circumstance; for the same bar, that, when properly hardened, may be made to lift twenty Ounces; when greatly over or greatly underheated, will not lift above six at the utmost.



trial to lift the same, though with some difficulty: the reason why this lifted more than formerly, I apprehend, was owing to the difference of the Shape of the Poker, from the bar it used to lift; which difference consists in a pretty large knob at the top, that is broad, and somewhat flatted.

From hence it seems likely, that it was not owing to any difference in the means of making them, that those Magnets just mentioned lifted seven or eight and twenty Ounces; especially as it is very probable, that the Method here offered to the Publick, is capable of bringing them to the greatest perfection, the nature of the Materials, they are made of, will admit; and this will appear from what follows.

It is very easy to communicate to a bar of Steel, a much greater degree of Virtue, than it will retain; but whether it be much or little beyond its due quantity, that any bar receives, it will lose what is above that quantity immediately; unless by some means or other it is preserved in that more strongly Magnetical State: this will appear very probable, from the *Method* of making Magnets; but, by the following *Experiments*, it will be put out of Doubt.



## EXPERIMENT I.

I took two semicircular Magnets, of the same size, each about two Ounces weight; and placing them with their ends together, so that they compleated the circle, I made them Magnetical according to the directions hereafter given; then trying to separate them immediately, I found, that less than six or seven pound was not sufficient to do it; but that, after they had been once separated, they might be separated again by three or four pound.

## EXPERIMENT II.

Another Experiment, almost the same with the former, was thus: I made Magnetical a small single bar armed, keeping an Iron wedge applied to it during the operation; I then tried what it would lift, and found that it lifted full one fifth part more, by the wedge, before it had been once separated, than after.

From hence it appears pretty evident, that it is not owing to any defect in the *Means* of making the bars Magnetical, that we cannot communicate a much greater degree of power to them, than that they will remain at; but rather to the *Inability* of the Materials, they are made of, to retain any more. If two  
Magnets



Magnets be placed with their Poles of the same denomination together, they will damage each other considerably ; and if several be so placed, some of them shall not only be quite spoiled, but perhaps even have their Poles converted : hence it is plain, if we conceive any Magnet, as divided into several, by Sections parallel to its Axis, that each of these will be endeavouring to damage all the rest. Now, if we suppose, that the hardness of the Steel is able to resist this Endeavour, in some measure ; this will very well account for any piece of Steel retaining its Magnetism to a certain degree, and for its not retaining any more than that ; since after the Power is become so great, as to be an overmatch for the resistance arising from the hardness of the Steel, the Magnet must necessarily reduce itself to such a power, as shall be just a balance for that resistance. And if we allow this reasoning to be just, the softer the Steel is, the less Magnetism it ought to retain, and the more easily it ought to be damaged : And this is actually the Case ; for a piece of spring-temper'd Steel will not retain near so much Magnetism, as hard Steel ; soft Steel will retain still less ; and Iron, which is the softest of all, scarce retains any : And this is evidently only want of *retention* ; for Iron will

*receive*



*receive* Magnetism the most easily of any; the soft Steel receives it much more easily, than the spring-temper'd; and the spring-temper'd much more easily, than the hard; for proof of this, see the Method of making Artificial Magnets, by means of three Iron bars, towards the End. The different ability in hard and spring-temper'd Steel to *retain* their Magnetism may be shewn thus:

#### EXPERIMENT.

Take two Magnets of an equal Size, one hard, and the other only of a spring temper; and placing their Poles of the same denomination together, rub them a little backwards and forwards for some time; and the spring-temper'd Magnet will be greatly damaged, or even quite spoiled, when the other will be hardly the worse.

From what has been said, it appears very probable then, that the most likely way of improving Magnets must be by employing better *Materials*; which, if there are any such, must probably be some kinds of Iron Ore of those sorts, that are capable of being made Magnetical; since different Steel, as far as has fallen under my experience, has made little or no difference; only that some has required greater exactness,



exactness, or a greater or less degree of heat, in the hardening.

Though Artificial Magnets have not been made to so great perfection, as at present, till very lately, there have not however been wanting some attempts to make them, and those with some degree of success. Several have thought of joining a good number of bars of Steel together, with Armour fixed to them, after having touched them on a good Loadstone; and this has succeeded tolerably well, so as that some Magnets, made after this manner, were little or not at all inferior to good Natural ones; and they had been generally much better still, had they been made of hard Steel, instead of soft or spring-temper'd; which was most commonly used, from a Notion, I suppose, that such bars would receive the most Virtue; whereas they only *receive* it with *more ease*, but will not *retain* it in so great a degree; and even what they do retain at first, they are much more subject to lose afterwards; and particularly so, when several bars are laid with their Poles of the same denomination together, which is the case in these compound Magnets.

The best Artificial Magnets, that ever were made till very lately, seem to be those of *Servington*



*vington Savery* Esq; † which were not much inferior to such, as are made by the Method here offer'd to the Publick, if they were such as he represents them ; and as his Method of making them seems to be founded on the true Principles of Magnetism, (for he appears to have understood the subject very well,) there can be no great reason to doubt the truth of what he asserts ; but I have not thought of trying myself whether his method would succeed, because it requires a good deal of time and trouble ; and could be of very little use, when I had a much easier and more expeditious way of making them unquestionably better. It seems strange however, that his Method has not hitherto been tried by others ; and that such Magnets are not before this, in common use, as they are greatly superior to the generality of the better sort of Natural Magnets, and perhaps to the best in use.

Though it is not altogether necessary to the present design, yet it may not perhaps be amiss, just to mention a few properties of Magnetical Bodies ; some of which are very necessary to be known by those, who have a mind to try Experiments, and for want of the knowledge

† See *Philos. Transf.* No. 414. or Vol. 6. Part 2d, Page 260. *Eames's* Abridgment.



of which, many experiments on this subject have fail'd, or wrong conclusions have been drawn from them : It will however be inconsistent with the brevity, I here propose, to give the proofs of them ; which therefore I must defer till some farther opportunity offers.

*First* then, Wherever any Magnetism is found, whether in the Magnet itself, or any piece of Iron, &c. excited by the Magnet, there are always found two Poles, which are generally called North and South ; and the North Pole of one Magnet always attracts the South Pole, and repels the North Pole of another ; and *vice versa*.

*Secondly*, This Attraction and Repulsion of Magnets is not at all hindered, or increased by the interposition of any Body whatsoever ; though sometimes in *appearance* perhaps it may be increased by the interposition of such Bodies, as become Magnetical when in contact with, or upon their approach towards the Magnets, between which they are placed.

† *Thirdly*, Each Pole attracts or repels exactly equally, at equal distances, in every direction.

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*Fourthly*,

† This is a Property, which perhaps those, who imagine Magnetism to depend upon a subtle fluid, may not be  
very



‡ *Fourthly*, The Magnetical Attraction and Repulsion are exactly equal to each other.

*Fifthly*,

very willing to admit, as being utterly inconsistent with such an Hypothesis ; but it is capable of being proved by a great variety of experiments.

The want of knowing this property of the Magnet has led several very accurate, and diligent enquirers, into considerable mistakes ; amongst whom was *Dr. Gilbert*, who wrote a very ingenious book, entitled *De Magnete*, about the end of *Queen Elizabeth's* Reign : Not being aware of this property, he concluded from some experiments he had made, not very irrationally, that the Needle was not attracted by the Magnet, but turned into its position by, what he calls, a disponent virtue ; which he supposed to surround the Stone, somewhat in form of an Atmosphere.

‡ Most people, who have mention'd any thing relating to this property of the Magnet, have agreed, not only that the Attraction and Repulsion of Magnets are not equal to each other, but that also they do not observe the same rule of increase and decrease : Their mistake in this matter arose from their not attending to the different degrees of Strength, that Magnets have, in different circumstances ; for two Magnets, that are placed with their attracting Poles towards each other, will have their power by that means increased ; and on the contrary, if their repelling Poles be placed towards each other, their power will be diminished ; and this increase or diminution of power will be in a greater or less degree, according as the Magnets are nearer to, or farther from each other ; whence in all the experiments made on this subject, the Attraction and Repulsion come perpetually nearer to an equality,



*Fifthly*, The Poles of Magnets are not at their Extremities, but at a little distance from thence; that is, Magnets are not so Magnetical at the Ends, as in the Middle; and in spring-temper'd and soft Steel Magnets, the Poles are generally somewhat farther from the Extremities than in hard ones.

\* *Sixthly*, The Attraction and Repulsion of Magnets decrease, as the Squares of the distances from the respective Poles increase.

This property, from some experiments I have made myself, and from those I have seen

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of

equality, the greater the distance of the two Magnets is, with which the experiments are made; and *vice versa*: And so great is the effect of Magnets on each other, that, when the repellent Poles of a large Magnet and a small one are brought into contact, the small one shall sometimes have its Repellency changed into Attraction.

\* There have been some, who have imagined, that the decrease of the Magnetic Attraction and Repulsion is inversely as the Cubes of the distances; others, as the Squares; and others, that it follows no certain ratio at all, but that it is much quicker at greater distances, than at small ones, and that it is different in different Stones: amongst these last is Dr. *Brook Taylor*, and *P. Muschenbroek*, who seem to have been pretty accurate in their experiments. [See *Philosoph. Transf.* No 368 and 390. or Vol. VI. Part II. Page 253 and 255. *Eames's* Abridgement.] The conclusions of these Gentlemen were drawn from their experiments,



of others, seems very probable ; but I do not pretend to lay it down as certain, not having made experiments enough yet, to determine it with sufficient exactness.

*Seventhly*, Magnets lift Iron, in an increased ratio of their Strength for *touching*, &c. and probably very nearly in a duplicate ratio.

experiments, without their being aware of the *third* property of Magnets, just mentioned ; which if they had made proper allowances for, together with the increase and diminution of power in the Magnets they tried their experiments with, all the irregularities, they complained of, (as far as appears from their relations of them,) might very well be accounted for, and the whole of their experiments coincide with the Squares of the distances inversely.



OF THE  
M E T H O D

OF MAKING

*Artificial Magnets.*

**B**EFORE we come to the Method of making Magnets, it may not be amiss to observe, that every Magnet has two Poles, (as they are called,) that is, two Points from which the attractive and repulsive powers seem to spread themselves, and to which they are directed; at the nearest parts to which, if other circumstances be the same, the Magnet always acts strongest: One of these is called the *North Pole*, and the other the *South*; and that is generally, and most properly called the † *South Pole*, which, if the Magnet was put into a little boat of Wood, or other Materials, large enough

† This is the Sense, in which they are always understood by the best Authors. [See *Gilbertus de Magnete*. Mr. *Savery* in the *Philos. Transf.* and several others, that have written upon this subject.] The reasons of calling them thus, may be seen in *Gilbertus de Magnete*; who says, he was the first, who called them after this manner.



to support it, and set afloat in water, would turn itself towards the *North*; and that is most properly called the *North Pole*, which would turn towards the *South*: this is the Sense, in which I would always be understood when I speak of them.

A *South Pole* of one Magnet always attracts the *North Pole* of another, and repels the *South Pole*; and on the contrary, a *North Pole* attracts the *South Pole*, and repels the *North Pole* of another: for this reason, if any one has a mind to touch a Needle, whose Point he would have turn towards the *North*, he begins by placing the other end of the Needle on the *North Pole* of the Magnet; and drawing it gradually along, he finishes with the Point; for the Point being last attracted, will continue to be attracted by the *North Pole* of the Magnet, and the other end will be repelled by it; and because the Point is attracted by a *North Pole*, it follows from what was said above, that it must be itself a *South Pole*, and consequently will turn towards the *North*, which is what was required.—Thus much to have premised may be sufficient.—Let us now proceed to the Method proposed for making Magnets.

Prepare a dozen bars of Steel, of about an ounce and three quarters weight each, six inches long,



long, and half an inch broad; let these be hardened with a *full* heat, but not with *too great* an one, for that is as bad as the other extreme: These bars should all be marked at one end, in order to distinguish one end from the other; and this may be done conveniently enough by nicking them with a Chizel, whilst hot. The *ends* of the bars should be cleaned up after hardening, either upon a smooth Stone, or Razor-grinder's Wheel, in order to make them shew to advantage in lifting of weights, and perhaps to make them a little better for touching Needles, &c. It may not be amiss too, for those who require beauty, to have the whole bar cleaned up after the same manner; but it is by no means necessary; for the bars that are hardened, as they come from the Forge, without any other labour bestowed upon them, are to the full as strong, perhaps rather stronger than the others.

The foregoing is proposed as a convenient Size and Shape. But if any other is liked better, either may be varied at pleasure, provided there be always observed a proper Length in the bars in proportion to their Thickness; an account of which may be seen in the Table hereafter inserted.

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As the bars here proposed are designed to be employed in making of Magnets of all Sizes, if any Person designs to make very large ones, he must have a great many more than a dozen; and it will likewise be very proper to have a good many of about half an inch longer, or half an inch shorter than the rest; the reasons of which will be seen hereafter.

The best sort of Steel, to make these bars of, is such as has no Veins of Iron in it; and probably in general, that which will receive the greatest degree of hardness, and with least heat. I have sometimes given the preference to double-refin'd Steel; sometimes to *German*; and as often to the common blistered Steel; which, I believe, I may venture to recommend as equal to any that I have tried; for the difference in Magnets, made of any Steel whatsoever, seems to arise chiefly from the different degrees of heat given them, in order to harden them; which will make a very great difference in the same Steel; but the blister'd Steel seems both as certain, and as little liable to any difference from little variations in the degree of heat given it, as any.

It will be proper, when any Magnet does not prove so good as expected, to harden it over again with a greater or less degree of heat,  
till



till it proves better : one of the best six-inch bars, I ever made, was one of the worst, till it had been hardened six or seven different times. As the common blistered Steel is as good for our purpose as any, a dozen such bars, as those described above, together with a proper box to put them in, may be afforded for a very small sum ; and such a Set is capable of touching a much larger Needle, than the best *Natural* Magnet yet discovered. In order to preserve these bars, it will be proper to have a box contrived, that shall have two pieces of Iron, of about an inch long each, (which will be about equal to the thickness of half a dozen of the Magnetical bars,) fixed upright over against each other at the distance of six inches from outside to outside. These pieces of Iron may be about a quarter of an inch square, or somewhat more, and should be filed pretty smooth on the sides : Against these are to be placed, with their Edges towards them, the dozen Magnetical bars, six on one side of them, and six on the other ; the six on one side with their South, or North Poles *one* way, and those on the other side with the same Poles the *contrary* way.— And here it is to be observed, that they must neither be taken out, nor put in all, or too many on a side at once ; for if two only be

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left,



left, with their Poles of the same denomination the same way, without one or more on the other side to counterbalance their effects, they will damage each other ; and if two of the same side be taken out together, or laid with their Poles of the same denomination together after they are taken out, they will also damage one another ; and this ought always carefully to be attended to. But, if at any time they are damaged, either for want of taking this precaution, or by any other Means, it will be proper to restore them, before they are used, after the manner prescribed for making of Magnets.

The bars being prepared as above, let it be proposed to make the marked ends of them South Poles, and the unmarked ends North Poles. To do this, place half a dozen of them in a line North and South, bringing the unmarked end of one to touch the marked end of the next throughout ; the marked ends lying towards the North, which will be some advantage to them : this done, take an *armed* Magnet, and placing it with both Poles upon one of the bars, the North Pole towards the marked end, (which is to be a South Pole,) and the South Pole towards the unmarked end, (which is to be a North Pole ;) slide it backwards



wards and forwards, from end to end of the whole line of bars, three or four times, taking care that they all touch ; then sliding it upon one of the middle bars, remove the two endmost into the middle, and pass over them again three or four times, but not going now to the end of the line ; because those at the ends, which were before in the middle, will have got more power, than they would have received where they are at present ; and they would lose some of it, if they were passed over again ; and for this reason, (*viz.* that the endmost bars will not receive so much power, as the middlemost,) the endmost bars before were directed to be removed into the middle. Having touched the bars in the foregoing manner, it will not be improper to turn them the other side uppermost, and touch them over again on that side, in the same manner, excepting the endmost bars, for the reasons above ; which, when the rest are touched, must be removed into the middle, and be touched in their turn.

If an *armed* Magnet is not to be had, take an *unarmed* one, either Natural or Artificial ; and laying the bars in a line as before, place the South Pole of the Magnet upon the marked end of the endmost bar, and slide it over the whole line to the end ; then taking that Pole off, place



the North Pole on, in its room ; not at the extremity of the bar, but towards the middle, and slide it back again ; then change the Poles again, (taking care to set the Magnet on at the middle of the bar,) and slide it to the other end, as at first : having done this four or five times, remove the two endmost bars into the middle, and placing the South Pole of the Magnet upon the marked end of them, slide it to the unmarked end ; and then, placing the North Pole upon the unmarked end, slide it to the marked end : Let this be repeated three or four times ; and turning the bars the other side upwards, repeat the same process again.

If the Magnets made use of in either of these Methods, should be too weak to communicate a sufficient degree of virtue to the bars to proceed with, (which may possibly be the case, especially in the last, and perhaps sometimes in the former, when the Poles are at a great distance;) it may not be amiss to touch the bars according to the foregoing directions, before they are hardened, when they will receive the Magnetic Virtue with much more ease ; then making the whole dozen Magnetical, according to the method hereafter given, till they are as strongly so, as they will be in their soft state, harden one half ; and having made them Magnetical



netical with the remaining half that are soft, harden those also, and proceed.

But if the Magnets be so very weak, as not to perform sufficiently even in this case ; recourse must be had to smaller bars of Steel, than those of six inches, and these soft too ; and if after all, this will not do, bars of Iron must be used, instead of the Magnets, after the manner described towards the end.

Having thus communicated a small degree of Magnetism to half a dozen of the bars, let the other half dozen, that remain yet unmagnetical, be laid in a line, in the same manner as the former ; and let A B in fig. 1st represent this line, consisting, according to the present supposition, of six, though in the figure only three are delineated, for want of room ; the line drawn cross at the end of each bar towards the right hand, represents the mark to distinguish that end from the other, and which in the present case we propose to make a South Pole : let C D, E F, represent the half dozen bars, already made Magnetical ; of which C D contains three, and E F three : these are made to lean against each other at the top, but are separated to a small distance at bottom, perhaps a tenth of an inch, or a little more ; though at first, while they are weak, they can hardly be brought



brought too near, provided they do not touch, which they must by no means do: it will be convenient to place between them a little bit of Wood, or any other Material, except Iron, to keep them at their distance. The three Magnets in C D, (for so we may properly enough call them, though their power as yet may be very small,) have all their South Poles downward, and placed towards the unmarked ends of the bars in the line, which are to be North Poles; and the three Magnets in E F, have all their North Poles downward and these are placed towards the marked ends of the bars, which are to be South Poles. [As in C D, E F, the marks upon the flat side of the Magnets are hid in several of them, there are little dots made on the edges, to distinguish the South Poles by, in the figure.] These six Magnetical bars being thus placed, slide them backward and forward three or four times the whole length of the line; then remove the two endmost bars of the line into the middle, as before, and slide the Magnetical bars over them again; then turn the bars in the line, the other side upward, and go over them again, in the same manner, excepting the endmost bars; which, when those in the middle are touched, are to be removed thither, to be touched in their turn.



turn. If the bars that were first made Magnetical had acquired a sufficient degree of virtue from the Magnet made use of to begin with, this second half dozen will, by the means here recommended, have acquired a stronger power than the former, which they were touched by; and therefore we may now lay down the first half dozen, in a line as before, and retouch them after the same manner with the latter, which have just received their Magnetism from them: this done, lay those down also again, and retouch them with the others: Repeat this a few times, first touching one Set, and then the other, till they have acquired as much Magnetism, as they will retain; or till they will receive no additional force, by any farther repetitions.

The six-inch bars made Magnetical after this manner, when properly harden'd, will singly lift by one Pole a piece of Iron, weighing a pound or better, if it is of a proper form; and six such bars, used according to the foregoing directions, will touch a line of fresh bars, of the same size, to their full perfection, in three or four times sliding over them; except the endmost, which must be always removed to the middle.

In the Method here given, three of the Magnetical bars (which are made use of to touch the others,)



others,) on one side, are set with their North Poles downward, and the other three on the other side, with their South Poles downward: Now as several Magnets laid together, with their Poles of the same denomination the same way, will greatly injure one another, unless they have something to counteract them; it is absolutely necessary, (and it ought always carefully to be observed,) not to place two of them, of a side, on together, but singly, one on one side, and one on the other, leaning them together, that they may rest against one another at the top: at the bottom they are preserved from injuring one another, by being placed upon the bar which is to be made Magnetical. In like manner they must not be taken off two of a side together; but singly, first on one side, and then on the other: But the readiest way of taking them off, is first to bring them to touch one another at the bottom, in the same manner as they do at the top, and then they may be removed at once, and upon occasion set on again; only observing not to separate them again, at the bottom, till they are placed upon the bar, they are to touch.

The two bars, at the ends of the line, are directed to be removed from thence in their turn; because they will not receive so much  
virtue



virtue there, as when placed in the middle ; the reason of this seems to be, that the fix Magnets, employed in touching, are endeavouring to make that Part of the bar which is *not* included between them, Magnetical in a *contrary* direction from that, which *is* included between them : Now this last is the direction of Magnetism design'd ; and consequently that former Endeavour is against us, and would do mischief, were it not by some means prevented ; and to prevent it, there are two causes that concur ; one, the power, by which the Steel resists in a certain degree all Endeavour, either to make it Magnetical, or to destroy its Magnetism ; the other, the power of the bars already in some measure Magnetical, which lye at both ends of the bar that is touched. Now this last Power is wanting at one extremity of those bars, that are placed at the ends ; and consequently not having a sufficient force fully to resist the *contrary* Endeavour of the Magnets employed in touching them, they become less Magnetical than the others, which have a sufficient force. Though in the line of bars, when making Magnetical, each bar has only one at each end to † support it against the *con-*

† Those Magnets, that are placed at the ends of the others, to preserve them, I call *Supporters*,



*trary* Endeavour of the fix, made use of to touch it, and this does very well ; yet some will receive some additional force by being supported with larger Magnets ; or instead of that, two or three of their own size, at each end ; those at the marked end all with their North Poles touching it, and those at the unmarked end all with their South Poles touching it : And because there will be two or three North Poles and as many South Poles together amongst the Supporters, at the other end from the bar to be touched, that have nothing to counteract them, it will be proper to place the South Pole of another Magnet amongst the North Poles, and the North Pole of another amongst the South Poles, that they may not hurt one another, which they otherwise will do.

If more Magnets, than fix, are used to touch bars of their own size, the *contrary* Endeavour will be greater ; and consequently they ought not to touch so well as fewer, unless the bars to be touched, are more strongly supported ; hence eight Magnets will not touch a line of bars so well, as fix ; for one supporter at each end, is not sufficient against the *contrary* Endeavour of so many.

As eight Magnets have a greater power than fix, and therefore must certainly communicate  
a greater



a greater power to a bar, if it is sufficiently supported; it may be asked, why should we not contrive to support it sufficiently, and make use of eight? To this I answer, that six are abundantly sufficient, to communicate as much power to a bar of their own size, as it will retain; and indeed, a good deal more: Four only are not much inferior to six; and two will give a power not a great deal less than either of those numbers. But if any one chuses to try eight, or a much greater number; (since it is not an easy matter to *support* against the *contrary* Endeavour of a great many,) he may, by the following means, touch a very small bar with almost any number he pleases. Place upon the bar to be touched any number, in the same manner as the six are ordered to be placed, *viz.* half with the South Poles downward towards one end; and the other half with the North Poles downward, towards the other end: And in case there be not otherwise convenient room to place so many as desired, they may be placed in double order upon the bar, only one half of each standing upon the bar, and the rest hanging over. These, instead of being made to lean at the top against each other to preserve them, may be made to lean with their edges against a piece of Iron, the



length of the bar to be touched ; or (if they are placed in double order,) against two such pieces of Iron ; then the two Sets, *viz.* those with their North Poles downward, and those with their South Poles downward, being placed so near each other as almost to touch in the middle, they may be gradually drawn from each other to the ends.

After this manner it may not be amiss to touch very small Needles, that are so slender as not to be able to support themselves against the *contrary* Endeavour, though they be touched with only two of the six-inch Magnets ; but in this case, there will be no occasion for the pieces of Iron mention'd above ; as it will not be at all necessary to use more than two Magnets to touch them with, which will want no connection to preserve them.

The manner of making Artificial Magnets, shewn in the foregoing Pages, may not improperly be called the *double Touch* : The reason why the Magnets used in it are to be placed in the manner directed, and why they give that direction of Magnetism which they do, cannot but be obvious enough to those, who have at all thought upon this subject : And many of the advantages the *double Touch* has over the *single*, or common way of touching, are also very plain.



plain. In the common way, the strength of only a Pole of one denomination, and of one Magnet can be applied ; and if this should not be strong enough, to give as great a degree of Magnetism to a bar of Steel, as it will retain, we cannot add to it, by applying several Magnets, with their Poles of the same denomination together, and touching upon them as if they were one ; since Magnets, placed with their Poles of the same denomination together, will greatly damage each other ; and if there be many of them, they will utterly spoil *several*, and greatly damage the *rest* : If therefore we wanted to touch a bar, that would require the strength of thirty of the six-inch bars, or more, after the manner of the *single Touch*, it would be utterly impossible ; since we could by no means collect force enough together, on account of their spoiling each other ; but if we take one half of the number of bars, and set them the other ends upward, over against the rest, after the manner in the *double Touch* ; they will then not only *preserve* each other almost entirely ; but it should seem, that they will also in some measure *encrease* the strength of the *ends*, which principally are concerned in touching.

There



There is a small advantage in the *double Touch*, arising from the two Sets of Poles being near each other ; so that they counteract, in some measure, the *contrary* Endeavour of one another.

Two Magnets will give more strength to a bar of their own size, when used after the manner of the *double Touch*, than a single Magnet equal to five of the former in strength, when applied after the manner of the *single Touch* : To set them however in a fair light, we ought to reckon the two as nearly equal to four ; since they have the double assistance of what they touch, after it is once become at all Magnetical ; and because all Magnets are much stronger in the middle, than they are at the ends, this may perhaps be nearly equal to the strength of the two Magnets, that are employed ; whence we ought to reckon a force nearly equal to four of the single bars, in this manner of touching, against a little more than the five in the single touch, where the Magnetism of the bar touched is of very little assistance, the part lying behind the Magnet employed in touching, being generally Magnetical by the force of it in a *contrary* direction, from that which lies before the Magnet, and consequently nearly counteracting it.

When



When I first thought of trying the *double Touch*, I promised myself great advantages from it ; seeing from other experiments a great probability, that the only thing wanting to make Steel very Magnetical, was to apply a sufficient force ; and by the means of the *double Touch*, I did not doubt of being able to apply almost any force, I would : But I did not expect that there would be so great a disproportion between it and the *single Touch*, as I have since found ; neither am I thoroughly satisfied, that there is not yet some other reason wanting to account for it, besides those already given ; which seem hardly sufficient to account for the whole of it.

All Needles should be touched *double*, and well supported, in order to be sure of giving them their full force : And it is well worth observing, that (for the reasons already assigned) care should be taken to make them of hardened Steel, and by no means of soft, or even spring-temper'd. And there is another advantage in making Needles hard, besides their retaining more power, and losing their power with more difficulty, *viz.* that the Poles of such, according to the *fifth* property of Magnets, mention'd Page 19, are nearer the extremities, and consequently act with more force to turn the Needle about.



For Mariner's † Needles to carry a Card, it will be very proper, to use such bars as those proposed for Magnets, (or however but little smaller in proportion to their Length,) with a hole in the middle, to let the pin, they are to rest on, pass through, and to fasten a cap in: The reason why I would recommend such large bars, is because the larger quantity of Steel we use, the more steadily and certainly the Compass will traverse, (provided the Needle be as

† Perhaps it may not be amiss to cover the Needles, made use of in the Sea Service, with a very thin coat of Linseed Oil, or some kind of Varnish, that may keep them from rusting, which is generally reckon'd to injure all Magnetical bodies that are liable to it. Needles may be touched through such a coat, as well as when naked, if *not* according to the method for making of Magnets, at *least* by a great number of bars applied after the method recommended for making small bars Magnetical. [See Page 35.] But probably the former Manner will be effectual; for I have given a very considerable strength to bars, though a card (which is many times thicker than such a coat,) was placed between them and the half dozen bars made use of to touch them. And *possibly* such a coat (especially of Linseed oil,) may make the Needles in time able to retain a greater degree of Magnetism, than they otherwise would do; for I have observed that *painted* Iron Casements are very often remarkably Magnetical; and it is generally said too, that they become much harder, and more brittle, for being painted; which perhaps may be the reason of their being so remarkably susceptible of Magnetism.



Magnetical in proportion to its bulk, as a more slender one; and this, such as are here proposed may be;) but they should not be much larger, for then that will not be the case.

There is one objection however to the making use of such large bars for Needles, especially if they are broad at the ends, which is this; that we cannot in such be always sure of having the \* Axis exactly in the middle of them: This however may in some measure be secured, by using bars pointed at the ends, such as fig. 2d. But as in such bars the Poles will be removed somewhat farther from the ends, and consequently the Needle will thereby be made *shorter*, if not less *Magnetical* too, in proportion to its size, it seems rather adviseable to adjust this inaccuracy; which may be done, by placing a long and slender Needle, without a Card, so as to be able to mark its variation, very exactly, from some fixed point; then removing the slender Needle, place that which is to carry the Card in its room; and adjust the Card upon it, according to the variation of the former: This may be better done on Shipboard, by stretching a line fore and aft, and placing

\* The Axis of a Needle, or Magnet, is a line passing through the two Poles; which is its line of direction, from which we must reckon its variation, &c.



both Needles under it, at a good distance from each other, that they may not affect one another ; and then adjusting them by the line.

There is an inconvenience will arise from increasing the weight of Mariners Needles ; *viz.* that the friction will be increased with it, and that in a greater proportion than the power of the Needles to turn themselves about, if they are made with metal caps, to turn upon metal points ; especially as we cannot well use Steel points at Sea, where every thing of Iron or Steel is extremely subject to rust. To remedy the friction in this case, it will be very proper to make use of caps, that have a little bit of Glass set in the top ; which will do full as *well*, and perhaps *better* than Agate, (which is sometimes used ;) at least it will be less trouble to work it into its proper form. This bit of Glass should have a hollow hemisphere ground on the underside, which should be very accurately polished ; it may be about a twentieth part of an inch in diameter, (more or less according to the size of the Needle it is to carry :) The point, that this is to turn upon, should be made either of Silver, or (which will be better) of Gold, made very hard by a good deal of allay ; these are not either of them subject to rust, especially not the Gold. Such caps and  
points



points as these, need be very little additional expence to any compasses; and compasses, furnished with such, may be depended upon to a much greater degree of exactness, than is necessary, or than it is possible to steer to, when there is not the least breath of air to ruffle the Water, or the least swell to cause any motion in the Ship; and this without the attendance of a person to tap the box, in order to take off the friction; which in the common compasses is often necessary, if it be required that they should traverse with any degree of accuracy.

I fasten'd such a cap as that described above, to a Needle that weighed somewhat more than eight Ounces, and which was 32 inches long: This Needle was set a going at the rate of about twenty five times round in a minute; and with this force, it made complete revolutions for the space of seventeen or eighteen minutes; after which it continued to vibrate about fifteen minutes longer, before it came to be quite at rest; and this it did upon a very irregular and blunt Brass point, which it had made so by its weight. The same Needle resting upon a sharp and well polished Steel point in Brass, would hardly vibrate at all. This Needle, with the glass cap, performed its smaller vibrations, which were nearly of equal time, in about thirteen seconds;



and though large Needles do not vibrate very fast, in proportion to the small ones, yet this would probably have vibrated considerably faster, had it been properly hardened ; for it was so long, that it was with some difficulty hardened at all by such workmen, as I was able to procure ; and therefore being at last too soft, it would not become near so Magnetical, as otherwise it might have been.

There are many Occasions, where these long Needles may be very useful ; and particularly, on account of their traversing to a much greater degree of exactness than the short ones, if they be well hung, as upon Glass, &c. which is almost absolutely necessary. There is one case where they may be of considerable service ; which therefore it may not be improper to mention.

It is said, that it is common to make use of Needles in Mines, (particularly of Coal,) in order to know the bearing of one place from another, that they may be able to sink a Shaft from above, over any place they will : But as in many sorts of Mines, and particularly those of Coal, there are often small quantities of Magnetical Iron Ore, they are very often thereby deceived, the Magnetical Iron Ore drawing the Needle out of its proper direction : Now the long Needles, beside their traversing to a greater degree



degree of exactness, are less liable to be disturbed by any small things, already † Magnetical, than the shorter ones. However, as, after all, the long Needles will be liable to be somewhat disturbed, by parcels of Magnetical Iron Ore, that may chance to lye near; the following method may be used, which will hardly ever fail of discovering such, if there be any; and will point out a way to rectify very nearly any error, that may be occasioned thereby. Stretch a line, as long as conveniently may be, in the Mine; and placing the Needle under it at one end, observe whether the Needle coincides with it, or at what angle it intersects it; then removing the Needle from place to place under the line, observe whether it always retains the same direction with respect to it; and if it does, its direction may be looked on as true, with hardly a possibility of being deceived: But if it varies in its direction in different places, then the place or places, where it deviates most from its general direction in other places, or where

† These large Needles indeed are rather more subject, than smaller ones, to be disturbed by any thing capable of being made Magnetical by *themselves*, as their power is stronger at a distance; for this reason all Iron, as Picks, &c. should be the more carefully kept at a good distance from them; and this indeed should be observed, when *any* Needles are used.



it varies quickest in moving the same distance along the line, must be nearest the occasion of its varying ; and then the farther one can remove from such place or places, the better. And after all, a little may be allowed for the varying of the Needle towards, or from such place or places, according as it shall appear, that its North or South Pole, which was there attracted, is nearest to, or farthest from any such. And in order to find which was attracted, remove the Needle to a little Distance, in a direction at right angles to the line, first on one side, and then on the other ; and observe on which side it deviates most from its general direction in other places : And then that end of the Needle which deviates there towards that *side*, or from the *line*, is the end attracted. But if, on either side of the line, the Needle should chance, when removed a little way, to deviate a good deal ; and when removed a little farther, to deviate not at all ; and when removed a little farther still, to deviate the other way ; then the substance attracting the Needle is nearly over or under it, at the point where it does not deviate at all : This therefore should be carefully observed, lest the Needle happening to be placed in this situation, where it does not deviate at all, the other should be taken for the  
side



side, where the attracting substance lyes, which may occasion a considerable error.

The six-inch bars are very sufficient for any purposes of touching, and they are such as are most likely to be generally useful; and as it is probable that Needles, of a greater thickness than they are, will hardly ever be used, the foregoing directions might perhaps be sufficient. But because some may chuse to make larger Magnets than those of six inches, as also of different Shapes, for the sake of variety and curiosity; and it will require some experience to be able to manage them conveniently, and to know how many of the six-inch bars are proper to be used in touching them, &c. the following directions are inserted.

All bars made use of for Magnets must be made of Steel, and harden'd according to the directions given for the six-inch bars: And in order to hold so great a number of six-inch bars, as must be employed in touching the large bars, it is necessary to make use of some kind of Frame; it being impossible to hold them in the hand, as one may the six for touching the small bars. The following is a description of a Frame for this purpose.

Let fig. 3d represent a Frame for holding several of the six-inch bars in order to touch  
large



large bars ; at the bottom of the Frame are placed two pieces of Wood, the ends of which are seen at A and B ; the distance of these pieces from each other must be a little more than the breadth of the bar to be touched, which is to slide easily between them : The design of these two pieces is to keep the Frame steady upon the bar, that it may not slide off sideways, when it should not ; but as it will be sometimes required to slide it off sideways, these must be either made so as to be taken off occasionally, or, they must be entirely omitted. The height of the Frame, without these two pieces, is six inches, being the length of the bars employed in touching ; it consists of four upright pieces framed together at the top and bottom by two open Frames, each of which is divided into two partitions by a cross bar, of about half an inch wide, in the middle : These partitions are to hold, one of them a Set of bars with their South Poles downward, and the other a Set of a like number with their North Poles downward ; and they are supposed wide enough to hold two breadths of the six-inch bars, which will be almost an inch and quarter ; and, because this is considerably more than the breadth of the bar to be touched, the two pieces A and B will be nearer together



gether than the two side pieces of the Frame ; and the six-inch bars, when placed in double order, will hang over the pieces A and B ; and therefore, that they may not rest upon them, and be thereby born off from the bar they are to touch, the three transverse pieces of the Frame at bottom are all supposed to be notched in a little way, to allow a little liberty. In the frame-work at the top are two hollows, one on each side, (that on the farther side only is visible in the Figure ;) these hollows are to be large enough to receive, each a piece of soft Iron, of about half an inch broad, and a quarter thick, or somewhat larger ; and yet leave as great a distance between them, as to contain two breadths of the six-inch bars ; that is, almost an inch and quarter, which is the breadth of the open partitions.

These two pieces of Iron are to be filed pretty smooth on that side, which is placed inwards ; they are designed to connect the bars in one partition of the Frame, with those in the other ; one half of the bars in each being to lean against each of them ; and, as leaning the bars against one another (as was done, when six only were employed,) cannot be conveniently applied, when many are made use of ; some such contrivance as this is absolutely necessary

G

cessary



cessary, to preserve the bars in each partition from spoiling one another ; which, because they all lye with their Poles of the same denomination the same way, they would certainly do, if those in one partition were not connected with those in the other. But this will preserve them, because the Poles of one Set lye in the contrary direction from those of the other.

The Frame being made as above, and the two pieces of Iron put into the hollows at the top, place it upon one bar of a line of large ones to be made Magnetical ; and set a \* proper number of the six-inch bars in each partition ; not all at once in either, but singly, one in one, and one in the other ; those in one, with their South Poles resting upon the bar, and their North Poles leaning against the pieces of Iron above ; and those in the other, with their North Poles resting upon the bar, and their South Poles leaning against the pieces of Iron above ; the North Poles resting upon the bar being towards the marked end of it, (which is to be a South Pole,) and the South Poles towards the unmarked end of it, (which is to be a North Pole :) This being done, slide the Frame backwards and forwards upon the line of bars, three or four

\* For the number of six-inch bars necessary to touch bars of different sizes, see the Table hereafter inserted.



times; and, turning them, touch them on every side, if square; or on the two flat sides, if flat; and remove the endmost into the middle, and pass over them again.

As the six-inch Magnets, so probably those of a larger size also, will often receive some additional strength by being supported by more than one of their own size at each end; if therefore it be required to give one of them the utmost power it will receive, it may not be amiss to support the ends of it by two or three of its own size; or instead of that, as many of the six-inch bars, as may be equivalent to them. But because so many cannot perhaps be always placed at the end of a bar, as may be required, it will do as well to place some of them at the sides, as near the end as conveniently may be. The ends of the Supporters, which do not touch the large bar, being, at either end of it, all Poles of the same denomination, must be again supported by a few others, that they may not damage one another; these must be supported by others; and those again perhaps by others, and so on; and this must always be observed, whenever a great number of Supporters are used, unless the Supporters at one end can be connected with those at the other, by means of a bar of Iron as large, or

G 2

some-



somewhat larger than the bar of Steel to be made Magnetical. And because the supporters may damage one another at the ends that lye next the bar supported, for want of sufficient force to counterbalance their effects, before the bar is become Magnetical; it will be convenient perhaps, after having once touched it, to place a fresh Set of supporters at the ends of it, and touch it over again. In making a bar, thus supported, Magnetical, because the Frame cannot be slid off at the ends of the bar, it will be necessary to leave out the two pieces of Wood A and B; and then it may be slid off sideways upon a bar of Iron, and on again from the bar of Iron, (as it shall be required,) in order to turn the Steel bar, that it may be touched on every side, &c. The bar of Iron is designed to connect the Poles of the two Sets in the Frame, which were before connected by the Steel bar; and they must not be taken off from one, and placed upon the other, but by sliding; because they must touch one, before they leave the other, that they may always continue connected.

The Frame above described is designed for touching such bars only, as require no more than two breadths of the six-inch bars; but if it be required to touch larger bars, that will take  
three,



three, four, or more breadths of them ; another sort of Frame, and bars of half an inch longer or half an inch shorter (such as were directed to be made at the beginning for this purpose) must be used ; the higher bars being to be placed in the middle, where they may be connected, by leaning against pieces of Iron, that pass over the tops of the shorter ones.

If the bars, to be made Magnetical, are so large as to require several breadths of the six-inch bars, it will perhaps be convenient to have the Frame, for holding them, so contrived, that they may be applied to all sides at once ; for otherwise, upon account of the great number of them that will be necessary, it is likely the outsides of the Sets will be driven to too great a distance from each other, to be able to do much service.

The foregoing manner, of applying the six-inch bars, will probably serve for touching bars of three inches square ; but if larger than these were to be made, perhaps it might be necessary, besides applying them to all the sides at once, to divide the two Sets, and use them after the † manner recommended for making small bars very Magnetical ; and in that case, it would be impossible to use too many to touch

† See Page 35.



with, and there would be no occasion for supporters.

The particular *Form* of Magnets is of very little consequence, with regard to their receiving the Magnetic Virtue, provided they have a sufficient length in proportion to their bulk; the Form therefore may be varied at pleasure.

The strait bars may be made either square, round, or flat; the flat ones however are most convenient for touching with, and perhaps too a little the strongest.

The strait bars may be pointed at the ends, in the manner of Fig. 2d in the Plate. This, in lifting, will make them shew to advantage upon a double account, *viz.* that they are thereby somewhat lighter, and that they will lift something more. These bars however I would not recommend for touching with; because, though they may be more Magnetical at their ends, than those that are not pointed, in proportion to the *size* of the ends; and therefore, coming to bear perhaps in as many points as the others, they may lift more; yet, the power in touching, not being only in the proportion of the points that bear upon the bar to be touched, but in a great measure also in the proportion of the Magnetism of the whole that is near bearing, they may not touch so well as those with the larger ends;



ends ; which have more Magnetism at their ends in the whole, though not so much in the same space.

Besides the strait bars, the following seem most likely to be such as will be more generally useful.

The *Horse-shoe Magnet* : This may be made either exactly in the form of an Horse Shoe, or such as is delineated in Fig. 4th, where a wedge of Iron is supposed to be applied to the Poles of it. The principal advantages of a Magnet of this Shape, are ; That it will lye in a narrower compass : A wedge of Iron may be applied to the two Poles of it ; by which means, being connected, the Magnet will be less likely to receive any injury by time, &c : It will lift by both Poles at once, and consequently lift at least double of what it would do, if it lifted only by one : It will serve instead of several small bars, for touching others, if it be made of a proper size, and its two Poles brought near enough to each other ; and it will be very convenient and expeditious for that purpose.

The *Annular Magnet* is a plain flat bar, bent flatways, instead of edgeways as the foregoing. This may be useful for several Experiments, and is of a very convenient shape to be armed.

The



The *Semicircular* Magnet may be bent either flatways as the *Annular*, or edgeways as the *Horse-shoe* Magnet. A Magnet of this sort is delineated in Fig. 5th. Two such as this may be conveniently placed together, in order to preserve each other: They are useful for touching small things *double*; and for several Experiments.

The *armed* Magnets, of all kinds, being rather things of Curiosity than Use, and vastly inferior to the *unarmed* ones, shall be mention'd bye and bye in the Method of improving *Natural* Magnets, &c.

The method of making the abovemention'd crooked Magnets is the same, as for the strait ones. The ends are to be supported in the same manner: The six-inch bars for touching must be placed in the same manner, and moved round, according to the bend of the bar, from end to end, and back again four or five times.

And now having said thus much, and given so full a description before of the method of making the strait bars Magnetical, I apprehend more will be needless.

After the like manner that a bar is made Magnetical, its Poles may be converted; by placing the bars which are to retouch it, with their North Poles towards the North Pole  
of



of it, and the South Poles towards the South Pole of it; and, in doing this, they should be placed on at the middle, (for otherwise they will perhaps be a little damaged by the Magnetism of it,) and should be slid once or twice backwards and forwards, before it is supported; and then that, which was the North Pole, must be supported as a South Pole, by North Poles; and that, which was the South Pole, as a North Pole, by South Poles.

To make a bar Magnetical, so that it shall have several Poles, support it at the places, where the Poles are designed to be, with Poles of a contrary denomination from those designed; and if any place is supported with South Poles, the next places on either side must be supported with North Poles, and contrariwise. Having done this, consider each piece included between any two Sets of supporters, as a separate bar, to be made Magnetical, with its South Pole towards the North Set of supporters, and its North Pole towards the South Set, and touch it accordingly. Magnets of this sort with a great many Poles will not do well, unless they are very long; and at best they are always weak, and will very soon spoil themselves; so that they should only be made occasionally.



In the following Table, the *first* Column has several lengths for bars, in feet and inches. The *second*, shews the weights, in pounds and ounces Avoirdupois, that bars of such lengths will bear. The *third* contains the number of six-inch bars proper to touch them with. And the *fourth*, the number of six-inch bars proper to support them with at each end.

Feet. Inch.	Pounds.	Ounces.	Touched by.	Supported by.
1	—	0. $\frac{1}{64}$	†	†
2	—	0. $\frac{1}{10}$		
3	—	0. $\frac{2}{7}$	— 2	— 1
4	—	0. $\frac{3}{5}$	— 4	— 2
5	—	1. $\frac{1}{13}$	— 6	— 2
6	—	1. $\frac{3}{4}$	— 6	— 2
8	—	4.	— 10	— 4
10	—	7.	— 14	— 5
1 — 0	— 1	1.	— 18	— 6
1 — 6	— 2	0.	— 36	— 12
2 — 0	— 4	3.	— 56	— 19
2 — 6	— 7	8.	— 74	— 24
3 — 0	— 12	0.	— 96	— 32
4 — 0	— 25	0.	— 170	— 57
5 — 0	— 45	8.	— 246	— 82
6 — 0	— 73	0.	— 330	— 110

The above Table is made out in vulgar fractions, as being the most commonly known;

† These two must be touched by two bars, after the manner of small bars; [See Page 35.] and need not be supported at all.

and



and the numbers are not accurately true, according to the proportion they were calculated by, but as near the truth as conveniently might be express'd in the fewest figures. The *size*, recommended for different Magnets, is not in a cubical proportion of their lengths, (for the larger ones require a greater length in proportion than the smaller,) but in a proportion, the Index of which is 2. 63; and this was taken from the proportion of the Magnet of six inches long, to that of a foot and half, and the rest were made out by analogy from them; and these seem to be not improper lengths for their bulk. But to determine this matter accurately, it will require a long experience. The above lengths however will probably be found generally to answer pretty well, though they are not recommended as precisely the best that can be. The *number* of six-inch bars, recommended for touching and supporting each Magnet, is (in round numbers) in proportion to the number of those used for the six-inch bars, as the weight of a piece of Steel of six inches long, and of the thickness of such Magnet, to the weight of one of the six-inch bars. But because the number, here recommended for touching, may possibly be rather too great for the larger bars, (for the resistance of the



Steel (as it should seem) is not so great, in proportion to the *contrary* Endeavour, in touching the larger ones, as the smaller,) it may not be amiss (if this should be found to be the case,) to touch them with somewhat fewer, till that number is discovered, with which they succeed the best.

The number of bars, employed as secondary supporters to the first Set of supporters, should not be fewer than one half, or at least one third of the first Set; and these again should be supported by half, or at least one third of their own number, and so on, till they finish at last with one.

If any Person chuses to make use of other sized bars, instead of those of six inches, either to touch or support with, the number of them must be such, that the whole surface of their ends, may be equal to that of the six-inch bars required for the same business.

The crooked Magnets of all sorts may be of the same length in proportion to their weight, as the strait ones, and they may be touched and supported by the same number of bars.

For those, who have not Sets of Magnetical bars to retouch with upon occasion, but only one or two, the following directions should be



be observed, in order to preserve them, as near as may be, in their full vigour.

A crooked Magnet of any sort may have a wedge of Iron applied to both Poles; or, if there are two of them, that have their Poles equally distant from one another, they may be placed with their Poles of contrary denominations together; but they must never be suffered to touch one another any where, but at the Poles.

One strait Magnet should always be kept with its South Pole towards the North, or in the \* Northern Magnetic hemisphere downward, and in the Southern upward. Two strait Magnets may be laid parallel to one another with their Poles of the same denomination contrary ways, having them connected by pieces of Iron passing cross their ends; but they should never be suffered to touch, except when they lye in the same line, and with Poles of contrary denominations.

A strait Magnet should never lift any Iron, &c. but by its South Pole in this Northern Magnetic hemisphere, and by its North Pole in the Southern Magnetic hemisphere; nor

\* By the Northern Magnetic hemisphere is meant all that part of the World, where the South Pole of a Needle dips; and by the Southern, all that part where the North Pole dips.

should



should it be lifted by any Iron, &c. but by the contrary Poles; and no Iron should be suffered to touch it any where, but at the ends.

*A Method of obtaining Magnetism by Means of three Iron bars.*

**I** Procured half a dozen small bars of *Steel*, which were cleaned up, but not hardened, weighing all together one Ounce: They were two inches and a half long, and a quarter of an inch broad, and were marked at one end, as the six-inch bars. One of these was placed nearly in the direction of the Needle, with the marked end (which it was proposed to make a South Pole,) towards the North: At each end of this was placed a large bar of *Iron*, in the same direction, and nearly horizontally, the North end being a little depressed: The bar of Iron at the North end was four feet long, and weighed thirty Pounds; and that at the South end was four feet and a half long, and weighed eighteen Pounds. This being done, an Iron Poker, weighing a little more than a Pound and six Ounces, was held nearly perpendicularly, the upper end inclining a little towards the South; the lower end of this (which was filed bright, that it might conveniently touch,) was placed upon the North end of the little Steel bar



bar (which was to be the South Pole :) The Poker being thus placed, the little bar was stroaked with it, from the North to the South end ; where it was taken off, and brought back at a little distance ; and being again placed as before, the little bar was stroaked with it, in the same manner ; and this was repeated twenty times, when it had acquired force enough to lift a small key, weighing about an eighth part of an Ounce. After this, it was again stroaked eighty times more, in the same manner as before ; and then it would lift a key weighing a quarter of an Ounce. It was now laid by, and three more of the Steel bars were made Magnetical after the same manner. Of the two remaining, one was placed between the two Iron bars, as before ; but, instead of the Poker, (which was now laid aside,) it was touched by the four already made in some degree Magnetical, after the manner directed for making of Magnets ; the two South Poles of the Touchers being kept at a little distance from the two North Poles, by a large Pin, which might be perhaps the thirtieth part of an inch in thickness : By this means the fifth bar acquired a good deal more power, than any of the four had. And the other remaining one being made Magnetical in the same way, these

two



two were substituted instead of two of the four; and those were touched in the same way, and substituted in the room of the remaining two of the four, which were touched likewise. After this manner the whole six bars of Steel were all touched round, three or four times; the last touched being always substituted in the room of the weakest of the four employed in touching, till they had all received as much virtue, as in their soft state they would retain; which was sufficient to make them lift nearly an Ounce and quarter each, by one Pole.

By these six, thus made Magnetical, and separated, as before, by a large Pin, a line of six-inch bars, that were hardened, was touched, according to the directions for making Magnets; and received by this means a power sufficient to make each of them lift about two Ounces, by one Pole; which was abundantly sufficient to make them † communicate to others a power greater than their own: For six others being touched by them, and they again by those, and this being repeated two or three

† The expression, of things communicating more power to others, than they have themselves, may perhaps seem unphilosophical; but, as it is not meant by this, that any thing passes from one to the other, it is hoped this manner of expression, as a common one, and for want of a better, may be excused.

times,



times, they acquired as great a power, as they would retain.

The reason of using such *small* bars of *Steel*, was, that such bars of *Iron* as were used, might be able to communicate to them a sufficient power; for though such bars of *Iron* will communicate a small degree of power to much larger bars of *Steel* than those here mentioned, even when hard; yet it will not be sufficient to make *them* communicate; and for the same reasons that the bars of *Steel* here used should be small, the bars of *Iron* should be large, *viz.* that they may have a greater power in proportion to them: And if the bars of *Steel* are small enough, and the bars of *Iron* large enough, (and those above mention'd seem to have been abundantly so;) and if too the proper directions for *placing* the bars, &c. be observed, the success need not be doubted.

For the same reason, that the bars of *Steel* used in the foregoing operation were small, they were also soft, *viz.* because such receive the Magnetic Virtue with vastly more ease than those that are not so; for the same bars hardened, and managed as before, did not in a long time that they were tried, receive near a sufficient degree of virtue to communicate to others: And perhaps they would not, if they had been tried



ever so long; at least they would have tired out a very ample share of patience first. The same bars, made of a spring temper, were tried; and received, in about six hundred strokes, as much virtue, as the soft ones with twenty, lifting about an eighth of an Ounce; and with several hundred strokes more, they would hardly receive any addition. These had however received force sufficient; for six of them, so touched, gave to six others, of their own size and temper, a greater degree of power than their own; and being improved from those again, and this being repeated backwards and forwards a few times, some of the six-inch bars were touched by them, and improved from one another, till they arrived at their full force.

From the spring-tempered bars being able to communicate their virtue, though they had not received near so strong a power as the soft ones, and that to others of a spring temper too, which receive the Magnetic virtue with so much more difficulty, (as is seen above;) it appears how abundantly sufficient the power attained by the soft ones was.

The reason of placing the Iron bars and Poker in the direction above described, is, that all Iron, which is not already fixedly Magnetical, becomes immediately Magnetical by being



ing placed in, or not very far from the direction of the Magnetic line. Now in the placing the Iron bars and Poker above, neither of them varied so much from this line, as not to become Magnetical by their position. But as this position of them is only fitted for some parts of the world, it will be necessary in others to alter it, according to the different direction of the Magnetic line. In all parts of the World, one or other of the following ways of placing the Iron bars will succeed. Place them either *first*, horizontally from North to South; or *secondly*, horizontally from East to West; or *thirdly*, perpendicularly; and let one end of the Poker or bar, with which the Steel bars are to be touched, be bent a little at one end, that it may come to bear, though the Poker be held nearly parallel to the other bars. This bent end of the Poker being placed upon *either* end of the little Steel bar to be touched, and the Poker being held in a direction nearly parallel to it, and with its other end towards the Iron bar, that lyes at the *opposite* end of the little Steel bar from that, upon which the bent end is placed, stroak with it to the other end; and there taking it off, replace it, and stroak again several times, till the little Steel bar has received a sufficient power.



Because Iron bars may sometimes have acquired a small degree of fixed Magnetism, by standing long in one position, (though this does not often happen;) it may not be amiss, when they are used, to retain the direction they have stood in, and to lay the same ends the same way as much as may be, in their proper position; or else to give them, after they are placed in their proper position, a few good strokes endways with a pretty heavy hammer; or they may be heated red hot, and laid to cool in that position; which will be the most certain way of any, to have them Magnetical in the right direction.

Beside the above manner, Magnetism may be obtained, in a small degree, by filing, drilling, and hammering; all which depend upon the same principle as the foregoing, *viz.* the position of the bodies concerned, in or near the Magnetic line. By hammering, which is the best of the three, I have communicated a small degree of Magnetism; and sufficient, with good Management to have proceeded with; but this way is slower, less certain, and gives not so great a power, as that I have already related,



*Of improving the Natural Magnets, &c.*

**I**N giving Magnetism to any substance, capable of receiving it ; in changing its direction ; or taking it away, and giving it in a contrary direction ; the whole difficulty is to apply a sufficient force, and in a proper direction. How this may be done in Steel bars, has been already shewn. To do it in the *Natural Magnets*, is somewhat more difficult, upon account of their great thickness, and small length ; and also upon account of a certain glassiness of the substance, which makes the bars, used in touching them, not apply so closely, as they will to Steel : This last circumstance makes them also more subject to damage one another. Whoever therefore tries such experiments with the *Natural Magnets*, must expect that the bars he employs will want retouching, after the operation.

If a Natural Magnet is to have its power increased, and it be a small one, and short, lay a great number of bars at its \* ends, after

\* There are no directions here given, for applying the proper Poles, and for some other such like things ; which, it is presumed, the Reader will be able easily to supply from what has been said before.



the manner of supporters; and this will be sufficient: If it be pretty long, so as to allow room for it, touch it also *double* with several bars (according to its bulk,) applying them to all sides at once. If it is to have its Poles changed, lay the supporters so, that the centre of their force shall, at each end, lye at the end of the line designed to be the Axis of the Magnet; and touch it *double*, as near as may be in that direction. If the Poles are to be converted, and the Magnet be long enough, touch it *double* according to the directions for converting the Poles of an Artificial Magnet; then support it, and touch it over again with fresh Touchers: Or if the Magnet is short, apply bars as supporters only, and change them two or three times; or else make use of the method described below.

As I have not had a sufficient Apparatus, or Opportunities of trying experiments upon the larger Magnets, I can only recommend the following, as what seems, if we may judge from analogy, the most convenient way of managing them, and most likely to be attended with success.

To encrease the power of a large Magnet, instead of placing supporters, put a large piece of Iron, the thickness and breadth of the Magnet,

net,



net, at each end of it. This piece of Iron should be, either three or four times as long, as it is thick; or else short, and three or four times as large at the end not touching the Magnet, as at the other: In the former of these ways there are to be placed on one side, in the other case, at the broad end, as many supporters as can conveniently stand there: This, if the Magnet be very short, may be sufficient; if it be long, it should be touched *double* besides. If the Poles of such a Magnet are to be changed, the middle of the end of the piece of Iron placed at each end of the Magnet, is to be placed against the end of the line designed to be the Axis. If the Poles are to be converted, it should be done first by touching *double*, if a sufficient force of Magnetical bars can be applied for this purpose; (for, as a great number of them are extremely subject to injure one another, this is somewhat difficult to do:) After the Poles are once converted, its power may be encreased as above. But if by touching *double*, the Poles will not be converted, place the Magnet between two pieces of Iron as before; then keeping them steady at their distance, remove the Magnet; and connecting the pieces of Iron by wedges of Iron, that may not stand in the way of it, when it is to be put in its place again, apply the supporters



porters as before, and putting the Magnet in its place take off the Iron wedges. This may be done two or three times, if it be found necessary, retouching the supporters every time.

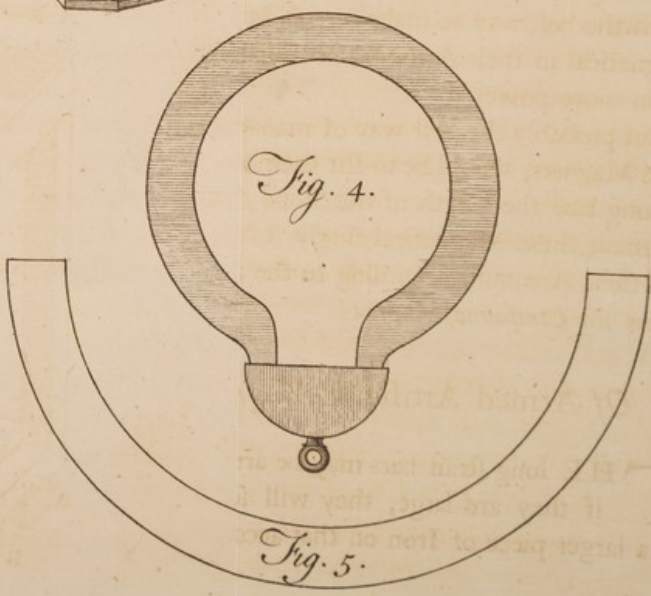
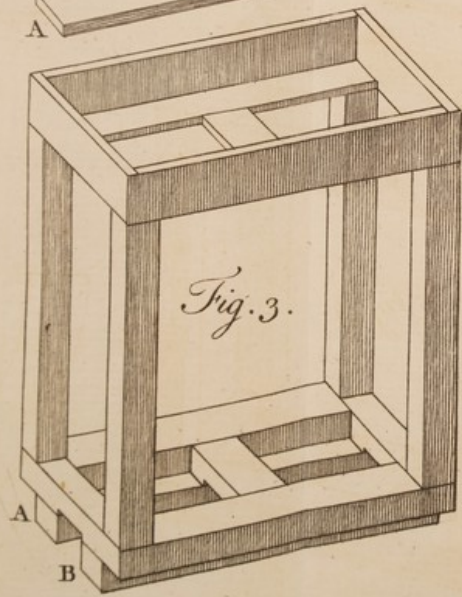
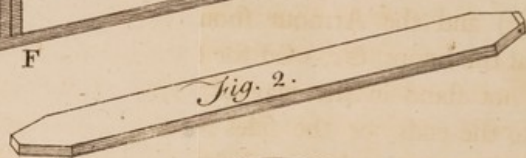
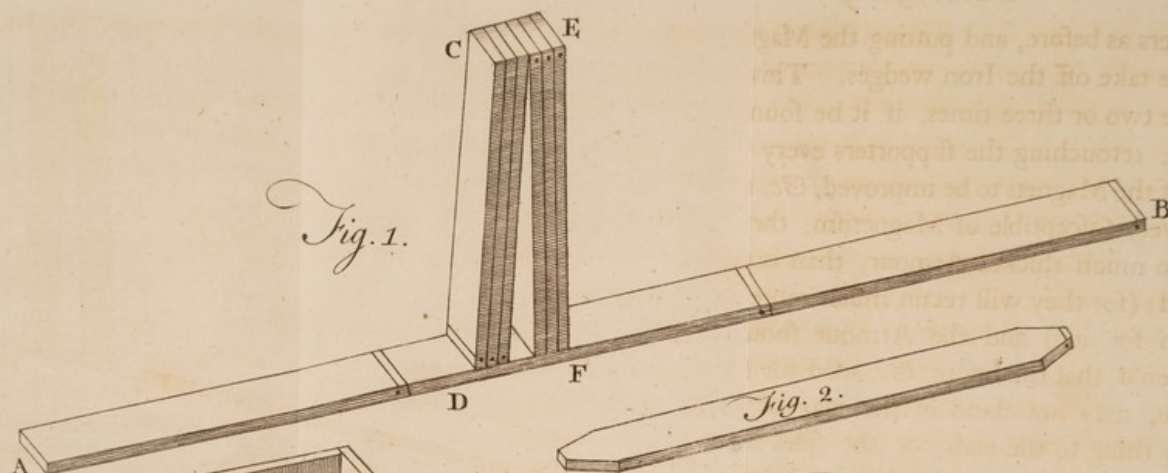
If the Magnets to be improved, &c. as above, be very susceptible of Magnetism, they should have much thicker Armour, than is generally used; (for they will retain much more Magnetism for it;) and the Armour should be so fasten'd, that the hoops, &c. used for that purpose, may not stand in the way of applying any thing to the ends, or the sides; for it is much the best way to make any short Magnets Magnetical in their Armour, because they will retain more power for it.

But probably the best way of managing very large Magnets, would be to slit them into several long bars the length of the Stone; and having made them Magnetical singly, to put them into their Armour, according to the directions below for *Compound* Magnets.

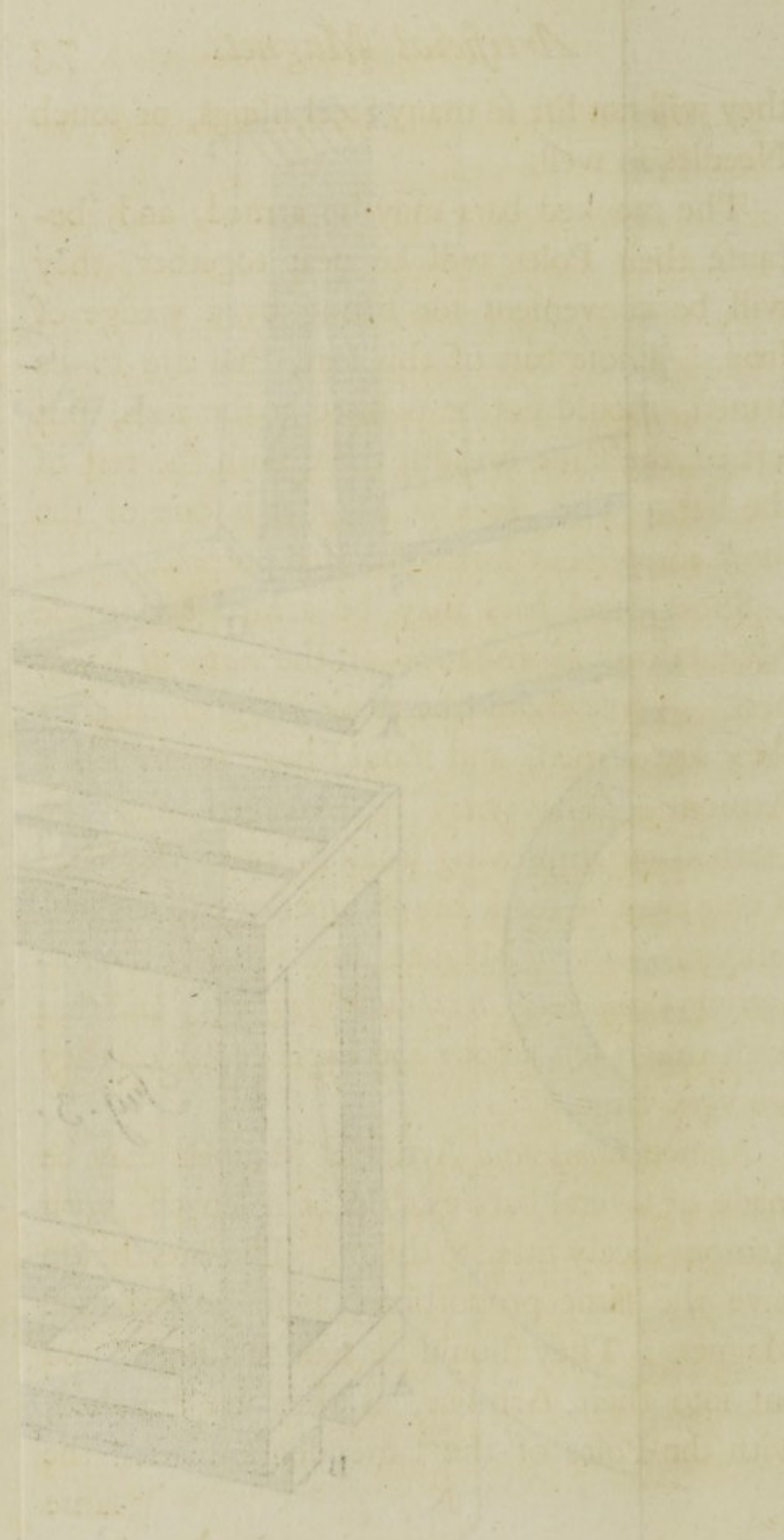
### *Of Armed Artificial Magnets.*

THE long strait bars may be armed, and if they are large, they will sometimes lift a larger piece of Iron on that account; but they











they will not lift so many Steel filings, or touch Needles so well.

The crooked bars may be armed, and, because their Poles will be near together, they will be convenient for lifting by a wedge of Iron. Those bars of this sort, that are to be armed, should not be pointed at the ends, but left of the same breadth there with the rest of the bar. The *Annular Magnet* is one of the most convenient forms for this purpose.

Short Steel bars may be armed and made Magnetical, in imitation of the *natural* Magnets. These should be made Magnetical after they are armed, and should have pretty thick Armour: They may be managed after the method for improving small Natural Magnets: These may be made much superior to the generality of *Natural* Magnets, and equal to the following *Compound Artificial* Magnets; and that with much less labour and expence, unless they are very large.

Armed *Compound* Artificial Magnets may be made of several bars exactly of a length, with Armour nicely fitted to them. The bars should have the same proportions, as single unarmed Magnets: They should be touched singly, and put into their Armour, as they are touched, with the Poles of the same denomination the



same way: The Armour should be pretty thick, and should have a wedge of Iron applied to it, whilst the bars are putting in, and till the whole is bound together and finished; for which reason the cap, that keeps the Armour together at bottom, should be put on before any of the bars are put in. The Iron wedge should always continue applied to the Magnet, but when it is used; for this will be a great preservation to it; though, with all this precaution, it will lose a great deal of its first strength, in a very little time.

An occasional Magnet of the same kind, and, on many accounts, preferable to the foregoing, may be thus made. Fix two small bars about three eighths of an inch square and two or three inches long (more or less at pleasure) to a board: Let them be parallel to each other, at the distance of six inches from outside to outside: They must stand at right angles to one edge of the board, and the ends may project half an inch beyond it, and should be filed away to about half the thickness of the rest of the bar; the faces of these ends then will be about as long again as broad, and the lengthways of them is to be parallel to the plain of the board; the faces themselves are to be at right angles to the plain of the board, and are  
both



both to lye exactly in the same plain with each other. To the edge of the board may be fixed a thin plate of Brass, between the two bars of Iron, reaching from one to the other, which may stand up above the plain of the board near an inch, and at right angles to it. When the Magnet is wanted, apply a wedge of Iron to the Iron bars projecting beyond the edge of the board, and having made any number of the six-inch Magnets, as Magnetical as may be, place them one by one with their edges against the two Iron bars, and their Poles of the same denomination the same way, pushing them close against the Brass plate, which will keep them from going beyond the edge of the board, and from turning over and lying flat-ways; having placed as many of the six-inch Magnets, as are required, in this manner, lay two or three doubles of Flannel, or something else that is soft and springy, over them, and with a board over that, that is screwed or otherwise fasten'd to the former board, press them against the two Iron bars. Such a Magnet as this may be easily taken to pieces and retouched, and set together again, as occasion shall serve: There will be no occasion for any great accuracy in the two Iron bars, (excepting their ends;) nor in the six-inch bars, in making them ex-



actly of a length, &c. and they will serve for other uses, when not wanted for this.

*Of Bodies susceptible of Magnetism.*

**T**H E S E are probably no others than Iron in some shape or other, or bodies that have a mixture of Iron in them.

Amongst these are in the *first* place, Iron and Steel.

*Secondly*, Almost all sorts of Iron Ore after Ignition, and some before, amongst which is the *Natural* Magnet, and several sorts of heavy shining, opake, black, or dark Chocolate-colour'd Sand, most if not all of which are Iron Ores. Sands of this sort, that are black, are found in *Portugal, Italy, Virginia, China, &c.* There is a dark Chocolate-coloured Sand too, which comes from *China*, very near akin to the black sort: The dark brown Sand amongst Emery is of the same kind; indeed the Emery itself is often, and not very improperly called an Iron Ore, though the part that is hardest, and principally useful in grinding, &c. seems rather to be a kind of *Spar* belonging to the Ore, than the Ore itself; but if this be the case, they are so minutely mixed, that it is impossible entirely to separate them. I have  
however



however found that part of the browner sort of Emery, which adheres to the Magnet, much more friable than the rest, opaque, and nearly black ; the other part being of a much lighter colour, and a great deal of it transparent. Amongst the blacker sort of Emery, there is but little transparent ; and that, which adheres to the Magnet, differs very little either in hardness or colour from the rest.

*Thirdly*, Amongst Bodies susceptible of Magnetism may be reckon'd most Brasses, and sometimes perhaps other Metals ; and particular Bricks, that have been a good deal burnt in the fire, but did not run. The Magnetism of these is owing, in all likelihood, to a small quantity of Iron mixed with them ; what is in the Brass may come from the *Lapis Calaminaris*, which is said to have often a small mixture of Iron in it : The like is observed of most sorts of Clay, especially the red sorts ; and this may account for it in Bricks.

### *Of Artificial Magnets made of Iron Ores, &c.*

**A**Rtificial Magnets may be made of any sort of Iron Ore, that is susceptible of Magnetism. The Iron Ore *Stones* may be  
saw'd



saw'd into *long Slips*, to make Magnets, in imitation of the unarmed Steel bars ; or into *shorter pieces*, in imitation of the natural Magnets. The Iron Ore *Sands* may be fixed by some cement, and being formed into a proper shape, may be made Magnetical: In doing this, as little cement as possible should be used, and such Sand, as is most retentive of the Magnetic Power, should be preferred ; the Sand from Emery is pretty good for this purpose.

### *Hints towards the improving of Magnets.*

**P**ROBably the Natural Magnets, that are very thick in proportion to their length, if properly cut, would make two or three Magnets able to *lift* more, and a great many better for *touching* than the entire one : They should be cut parallel to the Axis ; and some pieces may often be chosen, which are better than the rest ; and this should be attended to before the Stone is cut, that they may be as much as possible cut out by themselves, and not mixed with the parts that are worse.

Possibly some sorts of Iron Ore either ignited or otherwise, may be found more tenacious of Magnetism, than Steel. Such (if they be found) cut into long slips, of a due proportion, must  
make



make better Magnets than Steel, and consequently better *Needles* too. The best Natural Magnets may perhaps be such.

Possibly too some sorts of Iron Ore, that are very rigid, may not be capable of being made Magnetical, (by any force we can apply,) but in very small particles, as in sand or dust; and perhaps some that will not become Magnetical even in this form, either *before* or *after* Ignition, may yet be capable of becoming so *whilst* intensely heated: These probably (if there are any such,) would at least be extremely retentive of their Magnetism, and therefore Magnets made of such, after the manner above-mentioned for making Magnets of Magnetical Sands, (only that they must be made whilst the cement is hot, that the little Sands may be at liberty to dispose themselves according to order,) would be hardly liable to be impaired by time, &c.

It has been already hinted, that possibly Steel may be rendered more tenacious of the Magnetic power, by Linseed Oil; it may not therefore be amiss perhaps to try Steel bars (properly harden'd) that have been a long time laid in that, or some other Oil, which possibly may do as well.

And



And perhaps it may be better still, to make a piece of Steel more strongly Magnetical than the common bars will continue to be, and to keep it in that strongly Magnetical State, and to let it lye a long time in Oil. A Ring of Steel may be made very strongly Magnetical, the Magnetism going round and returning into itself; and this will continue in a strongly Magnetical State, for the same reasons that a Magnet will always be more Magnetical towards the middle, than at the ends. The Ring, after it has lain, as long as required, in the Oil, may be cut into two *Semicircular* Magnets.

*Some Uses of Magnets.*

BESIDES the uses of Magnets, in touching Needles for the more important purposes of Navigation, &c. which have been already sufficiently observed; it may not perhaps be amiss just to mention two or three others, that have occurred, of less consequence. They are these, which follow;

*First*, Iron Ores may generally be discovered to be such by the Magnet; for almost all of them (as was observed before,) will be attracted by it, either before or after Ignition, (though some require an Ignition of several hours first.)

A strong



A strong Magnet well hung, and used as a Needle, (as being the most sensible to any small attraction,) will best serve for this purpose.

*Secondly*, The Magnet will readily find, and separate any little bits of Iron or Steel from other things, and particularly Iron or Steel from those of other Metals.

And *lastly*, It will discover, whether Tools, &c. are made of Steel, or whether they are only Iron casehardened; for the Steel will receive a strong Touch, when the other will hardly receive any.

F I N I S.



