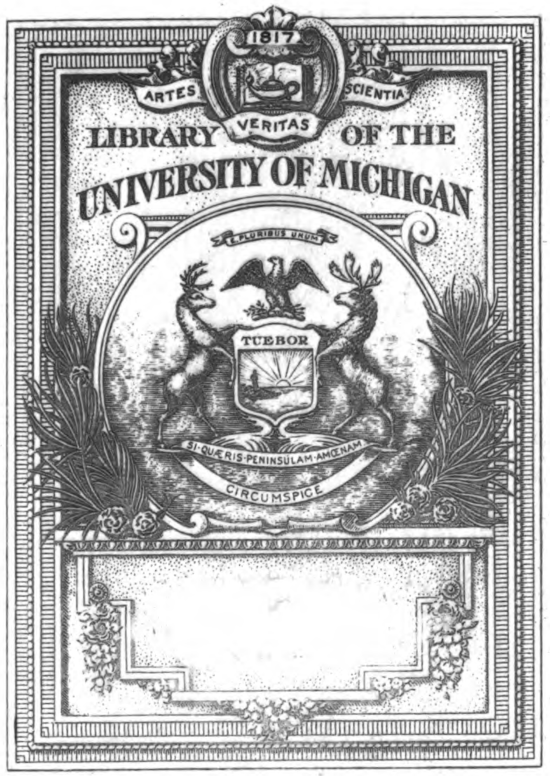
THE LETTER OF PETRUS PEREGRINUS

ON THE MAGNET, A.D. 1269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LETTER OF
PETRUS PEREGRINUS
ON THE MAGNET
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ON THE MAGNET, A.D. 1269

TRANSLATED BY

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WITH

INTRODUCTORY NOTICE

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INTRODUCTORY

THE magnetic lore of classic antiquity was scanty indeed, being limited to the attraction which the lodestone manifests for iron. Lucretius (99-55 B. C.), however, in his poetical dissertation on the magnet, contained in *De Rerum Natura*, Book VI.[1] recognizes magnetic repulsion, magnetic induction, and to some extent the magnetic field with its lines of force, for in verse 1040 he writes:

> Oft from the magnet, too, the steel recedes,
> Repelled by turns and re-attracted close.

And in verse 1085:

> Its viewless, potent virtues men surprise;
> Its strange effects, they view with wond'ring eyes

[1] With very few exceptions all the works referred to in this notice will be found in the Wheeler Collection in the Library of the American Institute of Electrical Engineers, New York.

When without aid of hinges, links or springs
A pendant chain we hold of steely rings
Dropt from the stone—the stone the binding source—
Ring cleaves to ring and owns magnetic force :
Those held above, the ones below maintain,
Circle 'neath circle downward draws in vain
Whilst free in air disports the oscillating chain.

The poet Claudian (365-408 A. D.) wrote a short idyll on the attractive virtue of the lodestone and its symbolism ; St. Augustine (354-430), in his work *De Civitate Dei*, records the fact that a lodestone, held under a silver plate, draws after it a scrap of iron lying on the plate. Abbot Neckam, the Augustinian (1157-1217), distinguishes between the properties of the two ends of the lodestone, and gives in his *De Utensilibus*, what is perhaps the earliest reference to the mariner's compass that we have. Albertus Magnus, the Dominican (1193-1280), in his treatise, *De Mineralibus*, enumerates different kinds of natural magnets and states some of the properties commonly attributed to them; the minstrel, Guyot de Provins, in a famous satirical poem, written about 1208, refers to the directive quality of the lodestone and its use in navigation, as do also Cardinal de Vitry in his *Historia Orientalis* (1215-1220); Brunetto Latini, poet, orator and philosopher, in his *Trésor des Sciences*, a veritable library, written in Paris in 1260; Raymond Lully, the Enlightened Doctor, in his treatise, *De Contemplatione*, begun in 1272, and Guido Guinicelli, the poet-priest of Bologna, who died in 1276.

The authors of these learned works were too busy with the pen to find time to devote to the close and prolonged study of natural phenomena necessary for fruitful discovery, and so had to content themselves with recording and discussing in their tomes the scientific knowledge of their age without making any notable additions to it.

But this was not the case with such contemporaries of theirs as Roger Bacon, the Franciscan, and his Gallic friend, Pierre de Maricourt, commonly called Petrus Peregrinus, the subject of the present notice, a man of academic culture and of a practical rather than speculative turn of mind. Of the early years of Peregrinus nothing is known save that he studied probably at the University of Paris, and that he graduated with the highest scholastic honors. He owes his surname to the village of Maricourt, in Picardy, and the appellation Peregrinus, or Pilgrim, to his having visited the Holy Land as a member of one of the crusading expeditions of the time.

In 1269 we find him in the engineering corps of the French army then besieging Lucera, in Southern Italy, which had revolted from the authority of its French master, Charles of Anjou. To Peregrinus was assigned the work of fortifying the camp and laying mines as well as of constructing engines for projecting stones and fireballs into the beleaguered city.

It was in the midst of such warlike preoccupations that the idea seems to have occurred to him of devising a piece of mechanism to keep the astronomical sphere of Archimedes in uniform rotation for a definite time. In the course of his work over the new motor, Peregrinus was gradually led to consider the more fascinating problem of perpetual motion itself with the result that he showed, at least diagrammatically, and to his own evident satisfaction, how a wheel might be driven round forever by the power of magnetic attraction.

Elated over his imaginary success, Peregrinus hastened to inform a friend of his at home; and that his friend might the more readily comprehend the mechanism of the motor and the functions of its parts, he proceeds to set forth in a methodical manner all the properties of the lodestone, most of which he himself had discovered. It is a fortunate circumstance that this Picard friend of his was not a man learned in the sciences, otherwise we would probably never have had the remarkable exposition which Peregrinus gives of the phenomena and laws of magnetism. This letter of 3,500 words is the first great landmark in the domain of magnetic philosophy, the next being Gilbert's *De Magnete*, in 1600.

The letter was addressed from the trenches at Lucera, Southern Italy, in August, 1269, to Sigerus de Foucaucourt, his "amicorum intimus," the dearest of friends. A more enlightened friend, however, than the knight of Foucaucourt was Roger Bacon, who held Peregrinus in the very highest esteem, as the following glowing testimony shows: "There are but two perfect mathematicians," wrote the English monk, "John of London and Petrus de Maharne-Curia, a Picard." Further on in his *Opus Tertium*, Bacon thus appraises the merits of the Picard: "I know of only one person who deserves praise for his work in experimental philosophy, for he does not care for the discourses of men and their wordy warfare, but quietly and diligently pursues the works of wisdom. Therefore, what others grope after blindly, as bats in the evening twilight, this man contemplates in all their brilliancy because he is a master of experiment. Hence, he knows all natural science whether pertaining to medicine and alchemy, or to matters celestial and terrestrial. He has worked diligently in the smelting of ores as also in the working of minerals; he is thoroughly acquainted with all sorts of arms and implements used in military service and in hunting, besides which he is skilled in agriculture and in the measurement of lands. It is impossible to write a useful or correct treatise in experimental philosophy without mentioning this man's name. Moreover, he pursues knowledge for its own sake; for if he wished to obtain royal favor, he could easily find sovereigns who would honor and enrich him."

This last statement is worthy of the best utterances of the twentieth century. Say what they will, the most ardent pleaders of our day for original work and laboratory methods cannot surpass the Franciscan monk of the thirteenth century in his denunciation of mere book learning or in his advocacy of experiment and research, while in Peregrinus, the mediævalist, they have Bacon's impersonation of what a student of science ought to be. Peregrinus was a hard worker, nor a mere theorizer, preferring, Procrustean-like, to make theory fit the facts rather than facts the theory; he was a brilliant discoverer who knew at the same time how to use his discoveries for the benefit of mankind; he was a pioneer of science and a leader in the progress of the world.

An analysis of the "Epistola" shows that

(*a*) Peregrinus was the first to assign a definite position to the poles of a lodestone, and to give directions for determining which is north and which south;

(*b*) He proved that unlike poles attract each other, and that similar ones repel;

(*c*) He established by experiment that every fragment of a lodestone, however small, is a complete magnet, thus anticipating one of our fundamental laboratory illustrations of the molecular theory;

(*d*) He recognized that a pole of a magnet may neutralize a weaker one of the same name, and even reverse its polarity;

(*e*) He was the first to pivot a magnetized needle and surround it with a graduated circle, Figs. 2 and 3.[1]

(*f*) He determined the position of an object by its magnetic bearing as done to-day in compass surveying; and

[1] It is probable that Flavio Gioja, an Italian pilot, some fifty years later, added the compass-card and attached it to the magnet.

(*g*) He introduced into his perpetual motion machine, Fig. 4, the idea of a magnetic motor, a clever idea, indeed, for a thirteenth century engineer.

This rapid summary will serve to show that the letter of Peregrinus is one of great interest in physics as well as in navigation and geodesy. For nearly three centuries, it lay unnoticed among the libraries of Europe, but it did not escape Gilbert, who makes frequent mention of it in his *De Magnete*, 1600; nor the illustrious Jesuit writers, Cabæus, who refers to it in his *Philosophia Magnetica*, 1629, and Kircher, who quotes from it in his *De Arte Magnetica*, 1641; it was well known to Jean Taisnier, the Belgian plagiarist, who transferred a great part of it verbatim to the pages of his *De Natura Magnetis*, 1562, without a word of acknowledgment. By this piece of fraud, Taisnier acquired considerable celebrity, a fact that goes to show the meritorious character of the work which he unscrupulously copied.

This memorable letter is divided into two parts: the first contains ten chapters on the general properties of the lodestone; the second has but three chapters, and shows how the author proposed to use a lodestone for the purpose of producing continuous rotation.

There are many manuscript copies of the letter in European libraries: the Bodleian has six; the Vatican, two; Trinity College, Dublin, one; the Bibliothèque Nationale, Paris, one; Leyden, Geneva and Turin, one each. The Leyden MS. has acquired special notoriety from a passage which appears near the end of it in which reference is made to magnetic declination and its value given: but Prof. W. Wenckebach, of The Hague, has shown[1] that the lines are spurious, having been interpolated in the manuscript in the early part of the sixteenth century.

The Leyden manuscript has also led some writers to believe in a fictitious author of the letter, one Peter Adsiger, or Petrus Adsigerus. As said above, Sigerus was the name of his countryman, to whom Peregrinus addressed his letter,

[1] Annali di Matematica Pura ed Applicata, 1865.

the *Epistola ad Sigerum*, from the trenches at Lucera, in August, 1269.

Magnetic declination was unknown to Peregrinus, else he would not have written the following words: "Wherever a man may be, he finds the lodestone pointing to the heavens in accordance with the position of the meridian" (Chapter X). Of course, the geographical meridian is the one here meant, as the necessity of a distinct magnetic meridian had not yet occurred to any one.

Nor was this important magnetic element known to Columbus when he sailed from the shores of the Old World in 1492 as appears from the surprise with which he noticed the deviation of the needle from North as well as from the consternation of his pilots. Columbus has the unquestionable merit of being the first to observe and record the change of declination with change of place.

The first printed edition of the Epistola, now very rare, was prepared by Achilles Gasser, a physician of Lindau, a man well versed in mathematics, astronomy, history and philosophy. The work was printed in Augsburg in 1558. A copy of this early print is among the treasures of the Wheeler collection in the library of the American Institute of Electrical Engineers, New York. It was from this text that the translation which follows was made.

Besides the Latin edition of Gasser, 1558, there is also that of Libri in his *Histoire des Sciences Mathématiques*, 1838; of Bertelli, 1868, and Hellmann, 1898. Bertelli's is a learned and exhaustive work in which the Barnabite monk, sometimes called by mistake, Barnabita, instead of Bertelli, collates and compares the readings of the two Vatican codices with other texts, adding copious references and explanatory notes. It appeared in the *Bulletino di Bibliografia e di Storia delle Scienze Matematiche e Fisiche* for 1868.

Of translations, we have that which Richard Eden made from Taisnier's pirated extracts, the first dated edition appearing in 1579. Cavallo's *Treatise on Magnetism*, 1800, also contains some of the more remarkable passages. The only complete English translation that we have, appeared in 1902 from the scholarly pen of Prof. Silvanus P. Thompson, of London. It is an *édition de luxe* beautifully rubricated, but limited to 250 copies. The translation was based on the texts of Gasser and Hellmann, amended by reference to a manuscript in the author's possession, dated 1391. We are informed that Mr. Fleury P. Mottelay, of New York, the learned translator of Gilbert's *De Magnete*, possesses a manuscript version by Prof. Peirce, of Harvard, of the Paris codex, of which he made a careful study in an endeavor to decipher the illegible parts.

PART I

THE LETTER OF PEREGRINUS

PART I

CHAPTER I

PURPOSE OF THIS WORK

DEAREST OF FRIENDS:

AT your earnest request, I will now make known to you, in an unpolished narrative, the undoubted though hidden virtue of the lodestone, concerning which philosophers up to the present time give us no information, because it is characteristic of good things to be hidden in darkness until they are brought to light by application to public utility. Out of affection for you, I will write in a simple style about things entirely unknown to the ordinary individual. Nevertheless I will speak only of the manifest properties of the lodestone, because this tract will form part of a work on the construction of philosophical instruments. The disclosing of the hidden properties of this stone is like the art of the sculptor by which he brings figures and seals into existence. Although I may call the matters about which you inquire evident and of inestimable value, they are considered by common folk to be illusions and mere creations of the imagination. But the things that are hidden from the multitude will become clear to astrologers and students of nature, and will constitute their delight, as they will also be of great help to those that are old and more learned.

CHAPTER II

QUALIFICATIONS OF THE EXPERIMENTER

YOU must know, my dear friend, that whoever wishes to experiment, should be acquainted with the nature of things, and should not be ignorant of the motion of the celestial bodies. He must also be skilful in manipulation in order that, by means of this stone, he may produce these marvelous effects. Through his own industry he can, to some extent, indeed, correct the errors that a mathematician would inevitably make if he were lacking in dexterity. Besides, in such occult experimentation, great skill is required, for very frequently without it the desired result cannot be obtained, because there are many things in the domain of reason which demand this manual dexterity.

CHAPTER III

CHARACTERISTICS OF A GOOD LODESTONE

THE lodestone selected must be distinguished by four marks—its color, homogeneity, weight and strength. Its color should be iron-like, pale, slightly bluish or indigo, just as polished iron becomes when exposed to the corroding atmosphere. I have never yet seen a stone of such description which did not produce wonderful effects. Such stones are found most frequently in northern countries, as is attested by sailors who frequent places on the northern seas, notably in Normandy, Flanders and Picardy. This stone should also be of homogeneous material; one having reddish spots and small holes in it should not be chosen; yet a lodestone is hardly ever found entirely free from such blemishes. On account of uniformity in its composition and the compactness of its innermost parts, such a stone is heavy and therefore more valuable. Its strength is known by its vigorous attraction for a large mass of iron; further on I will explain the nature of this attraction. If you chance to see a stone with all these characteristics, secure it if you can.

CHAPTER IV

HOW TO DISTINGUISH THE POLES OF A LODESTONE

I WISH to inform you that this stone bears in itself the likeness of the heavens, as I will now clearly demonstrate. There are in the heavens two points more important than all others, because on them, as on pivots, the celestial sphere revolves: these points are called, one the arctic or north pole, the other the antarctic or south pole. Similarly you must fully realize that in this stone there are two points styled respectively the north pole and the south pole. If you are very careful, you can discover these two points in a general way. One method for doing so is the following: With an instrument with which crystals and other stones are rounded let a lodestone be made into a globe and then polished. A needle or an elongated piece of iron is then placed on top of the lodestone and a line is drawn in the direction of the needle or iron, thus dividing the stone into two equal parts. The needle is next placed on another part of the stone and a second median line drawn. If desired, this operation may be performed on many different parts, and undoubtedly all these lines will meet in two points just as all meridian or azimuth circles meet in the two opposite poles of the globe. One of these is the north pole, the other the south pole. Proof of this will be found in a subsequent chapter of this tract.

A second method for determining these important points is this: Note the place on the above-mentioned spherical lodestone where the point of the needle clings most frequently and most strongly; for this will be one of the poles as discovered by the previous method. In order to determine this point exactly, break off a small piece of the needle or iron so as to obtain a fragment about the length of two fingernails; then put it on the spot which was found to be the pole by the former operation. If the fragment stands perpendicular to the stone, then that is, unquestionably, the pole sought; if not, then move the iron fragment about until it becomes so; mark this point carefully; on the opposite end another point may be found in a similar manner. If all this has been done rightly, and if the stone is homogeneous throughout and a choice specimen, these two points will be diametrically opposite, like the poles of a sphere.

CHAPTER V

HOW TO DISCOVER THE POLES OF A LODESTONE AND HOW TO TELL WHICH IS NORTH AND WHICH SOUTH

THE poles of a lodestone having been located in a general way, you will determine which is north and which south in the following manner: Take a wooden vessel rounded like a platter or dish, and in it place the stone in such a way that the two poles will be equidistant from the edge of the vessel; then place the dish in another and larger vessel full of water, so that the stone in the first-mentioned dish may be like a sailor in a boat. The second vessel should be of considerable size so that the first may resemble a ship floating in a river or on the sea. I insist upon the larger size of the second vessel in order that the natural tendency of the lodestone may not be impeded by contact of one vessel against the sides of the other. When the stone has been thus placed, it will turn the dish round until the north pole lies in the direction of the north pole of the heavens, and the south pole of the stone points to the south pole of the heavens. Even if the stone be moved a thousand times away from its position, it will return thereto a thousand times, as by natural instinct. Since the north and south parts of the heavens are known, these same points will then be easily recognized in the stone because each part of the lodestone will turn to the corresponding one of the heavens.

CHAPTER VI

HOW ONE LODESTONE ATTRACTS ANOTHER

WHEN you have discovered the north and the south pole in your lodestone, mark them both carefully, so that by means of these indentations they may be distinguished whenever necessary. Should you wish to see how one lodestone attracts another, then, with two lodestones selected and prepared as mentioned in the preceding chapter, proceed as follows: Place one in its dish that it may float about as a sailor in a skiff, and let its poles which have already been determined be equidistant from the horizon, i. e., from the edge of the vessel. Taking the other stone in your hand, approach its north pole to the south pole of the lodestone floating in the vessel; the latter will follow the stone in your hand as if longing to cling to it. If, conversely, you bring the south end of the lodestone in your hand toward the north end of the floating lodestone, the same phenomenon will occur; namely, the floating lodestone will follow the one in your hand. Know then that this is the law: the north pole of one lodestone attracts the south pole of another, while the south pole attracts the north. Should you proceed otherwise and bring the north pole of one near the north pole of another, the one you hold in your hand will seem to put the floating one to flight. If the south pole of one is brought near the south pole of another, the same will happen. This is because the north pole of one seeks the south pole of the other, and therefore repels the north pole. A proof of this is that finally the north pole becomes united with the south pole. Likewise if the south pole is stretched out towards the south pole of the floating lodestone, you will observe the latter to be repelled, which does not occur, as said before, when the north pole is extended towards the south. Hence the silliness of certain persons is manifest, who claim that just as scammony attracts jaundice on account of a similarity between them, so one lodestone attracts another even more strongly than it does iron, a fact which they suppose to be false although really true as shown by experiment.

CHAPTER VII

HOW IRON TOUCHED BY A LODESTONE TURNS TOWARDS THE POLES OF THE WORLD

IT is well known to all who have made the experiment, that when an elongated piece of iron has touched a lodestone and is then fastened to a light block of wood or to a straw and made float on water, one end will turn to the star which has been called the Sailor's star because it is near the pole; the truth is, however, that it does not point to the star but to the pole itself. A proof of this will be furnished in a following chapter. The other end of the iron will point in an opposite direction. But as to which end of the iron will turn towards the north and which to the south, you will observe that that part of the iron which has touched the south pole of the lodestone will point to the north and conversely, that part which had been in contact with the north pole will turn to the south. Though this appears marvelous to the uninitiated, yet it is known with certainty to those who have tried the experiment.

CHAPTER VIII

HOW A LODESTONE ATTRACTS IRON

IF you wish the stone, according to its natural desire, to attract iron, proceed as follows: Mark the north end of the iron and towards this end approach the south pole of the stone, when it will be found to follow the latter. Or, on the contrary, to the south part of the iron present the north pole of the stone and the latter will attract it without any difficulty. Should you, however, do the opposite, namely, if you bring the north end of the stone towards the north pole of the iron, you will notice the iron turn round until its south pole unites with the north end of the lodestone. The same thing will occur when the south end of the lodestone is brought near the south pole of the iron. Should force be exerted at either pole, so that when the south pole of the iron is made touch the south end of the stone, then the virtue in the iron will be easily altered in such a manner that what was before the south end will now become the north and conversely. The cause is that the last impression acts, confounds, or counteracts and alters the force of the original movement.

CHAPTER IX

WHY THE NORTH POLE OF ONE LODESTONE ATTRACTS THE SOUTH POLE OF ANOTHER AND VICE VERSA

AS already stated, the north pole of one lodestone attracts the south pole of another and conversely; in this case the virtue of the stronger becomes active, whilst that of the weaker becomes obedient or passive. I consider the following to be the cause of this phenomenon: the active agent requires a passive subject, not merely to be joined to it, but also to be united with it, so that the two make but one by nature. In the case of this wonderful lodestone this may be shown in the following manner: Take a lodestone which you may call *A D*, in which *A* is the north pole and *D* the south; cut this stone into two parts, so that you may have two distinct stones; place the stone having the pole *A* so that it may float on water and you will observe that *A* turns towards the north as before; the breaking did not destroy the properties of the parts of the stone, since it is homogeneous; hence it follows that the part of the stone at the point of fracture, which may be marked *B*, must be a south pole; this broken part of which we are now speaking may be called *A B*. The other, which contains *D*, should then be placed so as to float on water, when you will see *D* point towards the south because it is a south pole; but the other end at the point of fracture, lettered *C*, will be a north pole; this stone may now be named *C D*. If we consider the first stone as the active agent, then the second, or *C D*, will be the passive subject. You will also notice that the ends of the two stones which before their separation were together, after breaking will become one a north pole and the other a south pole. If now these same broken portions are brought near each other, one will attract the other, so that they will again be joined at the points *B* and *C*, where the fracture occurred. Thus, by natural instinct, one single stone will be formed as before. This may be demonstrated fully by cementing the parts together, when the same effects will be produced as before the stone was broken. As you will perceive from this experiment, the active agent desires to become one with the passive subject because of the similarity that exists between them. Hence *C*, being a north pole, must be brought close to *B*, so that the agent and its subject may form one and the same straight line in the order *A B*, *C D* and *B* and *C* being at the same point. In this union the identity of the extreme parts is retained and preserved just as they were at first; for *A* is the north pole in the entire line as it was in the divided one; so also *D* is the south pole as it was in the divided passive subject, but *B* and *C* have been made effectually into one. In the same way it happens that if *A* be joined to *D* so as to make the two lines one, in virtue of this union due to attraction in the order *C D A B*, then *A* and *D* will constitute but one point, the identity of the extreme parts will remain unchanged just as they were before being brought together, for *C* is a north pole and *B* a south, as during their separation. If you proceed in a different fashion, this identity or similarity of parts will not be preserved; for you will perceive that if *C*, a north pole, be joined to *A*, a north pole, contrary to the demonstrated truth, and from these two lines a single one, *B A C D*, is formed, as *D* was a south pole before the parts were united, it is then necessary that the other extremity should be a north pole, and as *B* is a south pole, the identity of the parts of the former similarity is destroyed. If you make *B* the south pole as it was before they united, then *D* must become north, though it was south in the original stone; in this way neither the identity nor similarity of parts is preserved. It is becoming that when the two are united into one, they should bear the same likeness as the agent, otherwise nature would be called upon to do what is impossible. The same incongruity would occur if you were to join *B* with *D* so as to make the line *A B D C*, as is plain to any person who reflects a moment. Nature, therefore, aims at being and also at acting in the best manner possible; it selects the former motion and order rather than the second because the identity is better preserved. From all this it is evident why the north pole attracts the south and conversely, and also why the south pole does not attract the south pole and the north pole does not attract the north.

CHAPTER X

AN INQUIRY INTO THE CAUSE OF THE NATURAL VIRTUE OF THE LODESTONE

CERTAIN persons who were but poor investigators of nature held the opinion that the force with which a lodestone draws iron, is found in the mineral veins themselves from which the stone is obtained; whence they claim that the iron turns towards the poles of the earth, only because of the numerous iron mines found there. But such persons are ignorant of the fact that in many different parts of the globe the lodestone is found; from which it would follow that the iron needle should turn in different directions according to the locality; but this is contrary to experience. Secondly, these individuals do not seem to know that the places under the poles are uninhabitable because there one-half the year is day and the other half night. Hence it is most silly to imagine that the lodestone should come to us from such places. Since the lodestone points to the south as well as to the north, it is evident from the foregoing chapters that we must conclude that not only from the north pole but also from the south pole rather than from the veins of the mines virtue flows into the poles of the lodestone. This follows from the consideration that wherever a man may be, he finds the stone pointing to the heavens in accordance with the position of the meridian; but all meridians meet in the poles of the world; hence it is manifest that from the poles of the world, the poles of the lodestone receive their virtue. Another necessary consequence of this is that the needle does not point to the pole star, since the meridians do not intersect in that star but in the poles of the world. In every region, the pole star is always found outside the meridian except twice in each complete revolution of the heavens. From all these considerations, it is clear that the poles of the lodestone derive their virtue from the poles of the heavens. As regards the other parts of the stone, the right conclusion is, that they obtain their virtue from the other parts of the heavens, so that we may infer that not only the poles of the stone receive their virtue and influence from the poles of the world, but likewise also the other parts, or the entire stone from the entire heavens. You may test this in the following manner: A round lodestone on which the poles are marked is placed on two sharp styles as pivots having one pivot under each pole so that the lodestone may easily revolve on these pivots. Having done this, make sure that it is equally balanced and that it turns smoothly on the pivots. Repeat this several times at different hours of the day and always with the utmost care. Then place the stone with its axis in the meridian, the poles resting on the pivots. Let it be moved after the manner of bracelets so that the elevation and depression of the poles may equal the elevation and depressions of the poles of the heavens of the place in which you are experimenting. If now the stone be moved according to the motion of the heavens, you will be delighted in having discovered such a wonderful secret; but if not, ascribe the failure to your own lack of skill rather than to a defect in nature. Moreover, in this position I consider the strength of the lodestone to be best preserved. When it is placed differently, i. e., not in the meridian, I think its virtue is weakened or obscured rather than maintained. With such an instrument you will need no timepiece, for by it you can know the ascendant at any hour you please, as well as all other dispositions of the heavens which are sought for by astrologers.

PART II

THE LETTER OF PEREGRINUS

PART II

CHAPTER I

THE CONSTRUCTION OF AN INSTRUMENT FOR MEASURING THE AZIMUTH OF THE SUN THE MOON OR ANY STAR ON THE HORIZON

HAVING fully examined all the properties of the lodestone and the phenomena connected therewith, let us now come to those instruments which depend for their operation on the knowledge of those facts. Take a rounded lodestone,[1] and after determining its poles in the manner already mentioned, file its two sides so that it becomes elongated at its poles and occupies less space. The lodestone prepared in this wise is then enclosed within two capsules after the fashion of a mirror. Let these capsules be so joined together that they cannot be sepa-

[1] A terrella, or earthkin.

rated and that water cannot enter; they should be made of light wood and fastened with cement suited to the purpose. Having done this, place them in a large vessel of water on the edges of which the two parts of the world, i. e., the north and south points, have been found and marked. These points may be united by a thread stretched across from north to south. Then float the capsules and place a smooth strip of wood over them in the manner of a diameter. Move the strip until it is equally distant from the meridian-line, previously determined and marked by a thread, or else until it coincides therewith. Then mark a line on the capsules according to the position of the strip, and this will indicate forever the meridian of that place. Let this line be divided at its middle by another cutting it at right angles, which will give the east and west line; thus the four cardinal points will be determined and indicated on the edge of the capsules. Each quarter is to be subdivided into 90 parts, making 360 in the circumference of the capsules. Engrave these divisions on them as usually done on the back of an astrolabe. On the top or edge of the capsules thus marked place a thin ruler like the pointer on the back of the astrolabe; instead of the sights attach two perpendicular pins, one at each end. If, therefore, you desire to take the azimuth of the sun, place the capsules in water and let them move freely until they come to rest in their natural position. Hold them firmly in one hand, while with the other you move the ruler until the shadow of the pins falls along the length of the ruler; then the end of the ruler which is towards the sun will indicate the azimuth of the sun. Should it be windy, let the capsules be covered with a suitable vessel until they have taken their position north and south. The same method, namely, by sighting, may be followed at night for determining the azimuth of the moon and stars; move the ruler until the ends of the pins are in the same line with the moon or star; the end of the ruler will then indicate the azimuth just as in the case of the sun. By means of the azimuth may then be determined the hour of the day, the ascendant, and all those other things usually determined by the astrolabe. A form of the instrument is shown in the following figure.

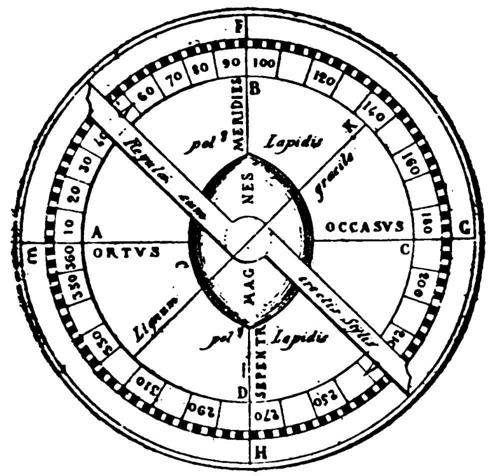

FIG. I.—AZIMUTH COMPASS

CHAPTER II

THE CONSTRUCTION OF A BETTER INSTRUMENT FOR THE SAME PURPOSE

IN this chapter I will describe the construction of a better and more efficient instrument. Select a vessel of wood, brass or any solid material you like, circular in shape, moderate in size, shallow but of sufficient width, with a cover of some transparent substance, such as glass or crystal; it would be even better to have both the vessel and the cover transparent. At the centre of this vessel fasten a thin axis of brass or silver, having its extremities in the cover above and the vessel below. At the middle of this axis let there be two apertures at right angles to each other; through one of them pass an iron stylus or needle, through the other a silver or brass needle crossing the iron one at right angles. Divide the cover first into four parts and subdivide these into 90 parts, as was mentioned in describing the former instrument. Mark the parts north, south, east and west. Add thereto a ruler of transparent material with pins at each end. After this bring either the north or the south pole of a lodestone near the cover so that the needle may be attracted and receive its virtue from the lodestone. Then turn the vessel until the needle stands in the north and south line already marked on the instrument; after which turn the ruler towards the sun if day-time, and towards the moon and stars at night, as described in the preceding chapter. By means of this instrument you can direct your course towards cities and islands and any other

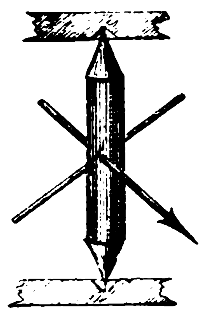

FIG. 2.—DOUBLE-PIVOTED NEEDLE

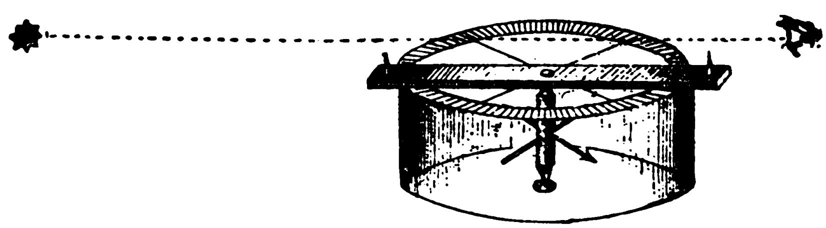

FIG. 3.—PIVOTED COMPASS

place wherever you may wish to go by land or sea, provided the latitude and longitude of the places are known to you. How iron remains suspended in air by virtue of the lodestone, I will explain in my book on the action of mirrors. Such, then, is the description of the instrument illustrated below. (See Figs. 2 and 3.)

CHAPTER III

THE ART OF MAKING A WHEEL OF PERPETUAL MOTION

IN this chapter I will make known to you the construction of a wheel which in a remarkable manner moves continuously. I have seen many persons vainly busy themselves and even becoming exhausted with much labor in their endeavors to invent such a wheel. But these invariably failed to notice that by means of the virtue or power of the lodestone all difficulty can be overcome. For the construction of such a wheel, take a silver capsule like that of a concave mirror, and worked on the outside with fine carving and perforations, not only for the sake of beauty, but also for the purpose of diminishing its weight. You should manage also that the eye of the unskilled may not perceive what is cunningly placed inside. Within let there be iron nails or teeth of equal weight fastened to the periphery of the wheel in a slanting direction, close to one another so that their distance apart may not be more than the thickness of a bean or a pea; the wheel itself must be of uniform weight throughout. Fasten the middle of the axis about which the wheel revolves so that the said axis may always remain immovable. Add thereto a silver bar, and at its extremity affix a lodestone placed between two capsules and prepared in the following way: When it has been rounded and its poles marked as said before, let it be shaped like an egg; leaving the poles untouched, file down the intervening parts so that thus flattened and occupying less space, it may not touch the sides of the capsules when the wheel revolves. Thus prepared, let it be attached to the silver rod just as a precious stone is placed in a ring; let the north pole be then turned towards the teeth or cogs of the wheel somewhat slantingly so that the virtue of the stone may not flow diametrically into the iron teeth, but at a certain angle; consequently when one of the teeth comes near the north pole and owing to the impetus of the wheel passes it, it then approaches the south pole from which it is rather driven away than attracted, as is evident from the law given in a preceding chapter. Therefore such a tooth would be constantly attracted and con-

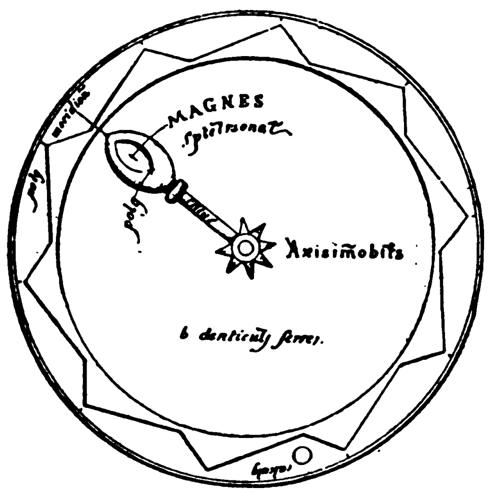

FIG. 4.—PERPETUAL MOTION WHEEL

stantly repelled. In order that the wheel may do its work more speedily, place within the box a small rounded weight made of brass or silver of such a size that it may be caught between each pair of teeth; consequently as the movement of the wheel is continuous in one direction, so the fall of the weight will be continuous in the other. Being caught between the teeth of a wheel which is continuously revolving, it seeks the centre of the earth in virtue of its own weight, thereby aiding the motion of the teeth and preventing them from coming to rest in a direct line with the lodestone. Let the places between the teeth be suitably hollowed out so that they may easily catch the body in its fall, as shown in the diagram above. (Fig. 4.)

Farewell: finished in camp at the siege of Lucera on the eighth day of August, Anno Domini MCCLXIX.

NOTES

EARLY REFERENCES TO THE MARINER'S COMPASS

THE following are the passages referred to in the introductory notice:

Abbot Neckam (1157-1217), in his *De Naturis Rerum*, writes:

"The sailors, moreover, as they sail over the sea, when in cloudy weather they can no longer profit by the light of the sun, or when the world is wrapped up in the darkness of the shades of night and they are ignorant to what point their ship's course is directed, these mariners touch the lodestone with a needle, which (the needle) is whirled round in a circle until when its motion ceases, its point looks direct to the north. (*Cuspis ipsius septentrionalem plagam respiciat.*)"

In his *De Utensilibus*, we read:

"Among other stores of a ship, there must be a needle mounted on a dart (*habeat etiam acum jaculo superpositam*) which will oscillate and turn until the point looks to the north, and the sailors will thus know how to direct their course when the pole star is concealed through the troubled state of the atmosphere."[1]

Alexander Neckam was born at St. Albans in 1157, joined the Augustinian Order and taught in the University of Paris from 1180 to 1187, after which he returned to England to take charge of a College of his Order at Dunstable. He was elected Abbot of Cirencester in 1213 and died at Kemsey, near Worcester, in 1217.

The satirical poem of Guyot de Provins, written about 1208, contains the following passage:

> The mariners employ an art which cannot deceive,
> By the property of the lodestone,
> An ugly stone and brown,
> To which iron joints itself willingly
> They have; they attend to where it points
> After they have applied a needle to it;
> And they lay the latter on a straw
> And put it simply in the water
> Where the straw makes it float.
> Then the point turns direct
> To the star with such certainty
> That no man will ever doubt it,
> Nor will it ever go wrong.
> When the sea is dark and hazy,
> That one sees neither star nor moon,
> Then they put a light by the needle
> And have no fear of losing their way.
> The point turns towards the star;

[1] The Chronicles and Memoirs of Great Britain and Ireland during the Middle Ages, by Thomas Wright (1863).

And the mariners are taught
To follow the right way.
It is an art which cannot fail.

Provins, from which Guyot took his surname, was a small town in the vicinity of Paris.

Cardinal Jacques de Vitry, in his *Historia Orientalis*, Cap. 89, writes:

"An iron needle, after having been in contact with the lodestone, turns towards the north star, so that it is very necessary for those who navigate the seas."

Jacques de Vitry was born at Argenteuil, near Paris, joined the fourth crusade, became Bishop of Ptolemais, and died in Rome in 1244. He wrote his "Description of Palestine," which forms the first book of his *Historia Orientalis*, in the East, between 1215 and 1220.

Albertus Magnus (1193-1280) in his *De Mineralibus*, Lib. II., Tract 3, Cap. 6, writes:

"It is the end of the lodestone which makes the iron that touched it turn to the north (*ad zoron*) and which is of use to mariners; but the other end of the needle turns toward the south (*ad aphron*)."

This illustrious Bavarian schoolman joined the Dominican Order in his youth, lectured to great audiences in Cologne, became bishop of Ratisbonne in 1260, and died in 1280. Thomas Aquinas the greatest of schoolmen, was among his pupils.

In the Spanish code of laws, begun in 1256, during the reign of Alfonso el Sabio, and known as *Las Siete Partidas*, we read:

"Just as mariners are guided during the night by the needle, which replaces for them the shores and pole star alike, by showing them the course to pursue both in fair weather and foul, so those who are called upon to advise the King must always be guided by a spirit of justice."

Brunetto Latini, in his *Trésor des Sciences*, 1260, writes:

"The sailors navigate the seas guided by the two stars called the tramontanes, and each of the two parts of the lodestone directs the end of the needle to the star to which that part itself turns."

Brunetto Latini (1230-1294) was a man of great eminence in the thirteenth century; Dante was among his pupils at Florence. For political reasons, he removed to Paris, where he wrote his *Trésor* and also his *Tesoretto*. He visited Roger Bacon at Oxford about 1260.

In his treatise *De Contemplatione*, begun in 1272, Raymond Lully writes:

"As the needle, after having touched the lodestone, turns to the north, so the mariner's needle (*acus nautica*) directs them over the sea."

Lully was born at Palma in the Island of Majorca in 1236; he joined the Third Order of St. Francis, dying in 1315.

Ristoro d'Arezzo, in his *Libro della Composizione del Mundo*, written in 1282, has the following:

"Besides this, there is the needle which guides the mariner, and which is itself directed by the star called the tramontane." [1]

The following metrical translation of a poem by Guido Guinicelli, an Italian priest, 1276, is from the pen of Dr. Park Benjamin, of New York:

In what strange regions 'neath the polar star
May the great hills of massy lodestone rise,
Virtue imparting to the ambient air
To draw the stubborn iron; while afar
From that same stone, the hidden virtue flies
To turn the quivering needle to the Bear
In splendor blazing in the Northern skies.

The above extracts show that the directive property of the magnetic needle was well known in England, France, Germany, Spain and Italy in the thirteenth century. In the passage from Neckam, the *acum jaculo superpositam* has been construed by some to mean a form of pivoted needle, while in the letter of Peregrinus, 1269, the double pivoted form is clearly described.

[1] The pole-star was thus named in the south of France and the north of Italy because seen beyond the mountains (the Alps).