length. I also claim the manner, substantially as herein described, of connecting or jointing the core bars, for forming cores for elbows or branch pipes, viz: by means of wooden wedges, which are the means of holding the bars together while the core is being formed; said wedges being burnt out by the liquid metal, when poured into the mould, and allowing the cores to be withdrawn."

- 13 For an *Improvement in Moulds for Uniting Steel to Cast Iron*; Charles Peters, Trenton, New Jersey.

Claim.—"What I claim as my invention is, the use of a solid base to moulds, in which steel or wrought iron is to be welded to cast iron, with an aperture in the same, so that by means thereof, the said steel or wrought iron can be subjected to the heat of the furnace, while in the mould."

14. For an *Improvement in Winnowers*; George F. S. Zimmerman, Charlestown, Va. ~

Claim.—"Having fully described the construction, operation, and advantages of my improved threshing and cleaning machine, what I claim as new is, the invention, use, and application of the perforated vibrating table, arranged to a sloping bottom, or platforms, the parallel, saw like strips, or straw pushers, combined with an oscillating rake and straw beaters, or curved prongs; the whole combined and working with the oscillating hinged standard and suspending straps, as shown in diagram and substantially as set forth. I do not, however, claim the invention of a combined threshing, separating, and winnowing machine, but only such parts as are set forth in my specification."

15. For an *Improvement in Gas Metres*; Edward R. Hallam, and Thomas B. Barnard, Brooklyn, New York, Assignors to E. R. Hallam, New Haven, Connecticut.

Claim.—"What we claim as our invention is, the within described method of constructing metres, with one cylinder working within another, so that the gas passes alternately into the inner cylinder and out of the space above it, and then out of the inner cylinder, while the supply enters the space above it; the gas being changed in its course or direction, by valves, as herein described."

16. For an *Improvement in Surgical Instruments for Examining the Ear, &c.*; H. Le Riemondie, of New Orleans, Louisiana; ante-dated October 23, 1852.

"The object of my invention is so to construct such an instrument, that the part to be examined, is seen by light reflected upon it from the interior of the instrument."

Claim.—"What I claim as my invention is, the construction of an instrument for examining the interior of the ear, nose, eye, or other part of the human system, by the combination of the reflectors, the lens, case, tubes, and lamp, substantially in the manner herein specified."

MECHANICS, PHYSICS, AND CHEMISTRY.

On the Physical Lines of Magnetic Force. By Prof. FARADAY.*

On a former occasion, certain lines about a bar magnet were described and defined, (being those which are depicted to the eye by the use of iron filings sprinkled in the neighborhood of the magnet,) and were recommended as expressing accurately the nature, condition, direction, and amount of the force in any given region either within or outside of the bar. At that time the lines were considered in the abstract. Without departing from or unsettling anything then said, the inquiry is now entered upon, of the possible and probable *physical existence* of such lines. Many powers act manifestly at a distance; their physical nature is incomprehensible to us: still we may learn much that is real and positive about them, and amongst other things something of the condition of the space between the body acting and that acted upon, or between the two mutu-

* From the London Athenæum, July, 1852.

ally acting bodies. Such forces are presented to us by the phenomena of gravity, light, electricity, magnetism, &c. These when examined will be found to present remarkable differences in relation to their respective lines of forces; and at the same time that they establish the existence of real physical lines in some cases, will facilitate the consideration of the question as applied especially to magnetism. When two bodies, *a*, *b*, gravitate towards each other, the line in which they act is a straight line, for such is the line which either would follow if free to move. The attractive force is not altered, either in *direction* or *amount*, if a third body is made to act by gravitation or otherwise upon either or both of the first two. A balanced cylinder of brass gravitates to the earth with a weight exactly the same, whether it is left like a pendulum freely to hang towards it, or whether it is drawn aside by other attractions or by tension, whatever the amount of the latter may be. A new gravitating force may be exerted upon *a*, but that does not in the least affect the amount of power which it exerts towards *b*. We have no evidence that *time* enters in any way into the exercise of this power, whatever the distance between the acting bodies, as that from the sun to the earth, or from star to star. We can hardly conceive of this force in one particle by itself; it is when two or more are present that we comprehend it: yet in gaining this idea we perceive no difference in the character of the power in the different particles; all of the same kind are *equal*, *mutual*, and *alike*. In the case of gravitation, no effect which sustains the idea of an independent or physical line of force is presented to us; and as far as we at present know, the line of gravitation is merely an ideal line representing the direction in which the power is exerted. Take the sun in relation to another force which it exerts upon the earth, namely, its illuminating or warming power. In this case rays (which are lines of force) pass across the intermediate space; but then we may affect these lines by different media applied to them in their course. We may alter their direction either by reflection or refraction; we may make them pursue curved or angular courses. We may cut them off at their origin, and then search for and find them before they have attained their object. They have a relation to *time*, and occupy eight minutes in coming from the sun to the earth: so that they may exist independently either of their source or their final home, and have in fact a clear, distinct physical existence. They are in extreme contrast with the lines of gravitating power in this respect; as they are also in respect of their condition at their terminations. The two bodies terminating a line of gravitating force are alike in their actions in every respect, and so the line joining them has like relations in both directions. The two bodies at the terminals of a ray are utterly unlike in action: one is a source, the other a destroyer of the line; and the line itself has the relation of a stream flowing in one direction. In these two cases of gravity and radiation, the difference between an abstract and a physical line of force is immediately manifest. Turning to the case of static electricity, we find here attractions (and other actions) at a distance as in the former cases; but when we come to compare the attraction with that of gravity, very striking distinctions are presented, which immediately affect the question of a physical line of force. In the first place, when we examine the bodies bounding or terminating the lines of attraction, we

find them as before, mutually and equally concerned in the action; but they are not alike: on the contrary, though each is endued with a force which, speaking generally, is of the like nature, still they are in such contrast that their actions on a third body in a state like either of them are precisely the reverse of each other,—what the one attracts the other repels; and the force makes itself evident as one of those manifestations of power endued with a dual and antithetical condition. Now with all such dual powers, attraction cannot occur unless the two conditions of force are present and in face of each other through the lines of force. Another essential limitation is, that these two conditions must be exactly equal in amount, not merely to produce the effects of attraction, but in every other case; for it is impossible so to arrange things that there shall be present or be evolved more electric power of the one kind than of the other. Another limitation is, that they must be in physical relation to each other; and that when a positive and a negative electrified surface are thus associated, we cannot cut off this relation except by transferring the forces of these surfaces to equal amounts of the contrary forces provided elsewhere. Another limitation is, that the power is definite in amount. If a ball *a* be charged with 10 of positive electricity, it may be made to act with that amount of power on another ball *b* charged with 10 of negative electricity; but if 5 of its power be taken up by a third ball *c* charged with negative electricity, then it can only act with 5 of power on ball *a*, and that ball must find or evolve 5 of positive power elsewhere: this is quite unlike what occurs with gravity, a power that presents us with nothing dual in its character. Finally, the electric force acts in curved lines. If a ball be electrified positively and insulated in the air, and a round metallic plate be placed about 12 or 15 inches off, facing it and uninsulated, the latter will be found, by the necessity mentioned above, in a negative condition; but it is not negative only on the side facing the ball, but on the other or outer face also, as may be shown by a carrier applied there, or by a strip of gold or silver leaf hung against that outer face. Now, the power affecting this face does not pass through the uninsulated plate, for the thinnest gold leaf is able to stop the inductive action, but round the edges of the face, and therefore acts in curved lines. All these points indicate the existence of physical lines of electric force:—the absolutely essential relation of positive and negative surfaces to each other, and their dependence on each other, contrasted with the known mobility of the forces, admit of no other conclusion. The action also in curved lines must depend upon a physical line of force. And there is a third important character of the force leading to the same result, namely, its affection by media having different specific inductive capacities. When we pass to dynamic electricity, the evidence of physical lines of force is far more patent. A voltaic battery having its extremities connected by a conducting medium, has what has been expressly called a current of force running round the circuit, but this current is an axis of power having equal and contrary forces in opposite directions. It consists of lines of force which are compressed or expanded according to the transverse action of the conductor, which changes in direction with the form of the conductor, which are found in every part of the conductor, and can be taken out from any place by channels properly appointed for the purpose; and nobody doubts that they are physical lines of force. Finally, as

regards a magnet, which is the object of the present discourse. A magnet presents a system of forces perfect in itself, and able, therefore, to exist by its own mutual relations. It has the dual and antithetic character belonging to both static and dynamic electricity; and this is made manifest by what are called its polarities, *i. e.* by the opposite powers of like kind found at and towards its extremities. These powers are found to be absolutely equal to each other; one cannot be changed in any degree as to amount without an equal change of the other; and this is true when the opposite polarities of a magnet are not related to each other, but to the polarities of other magnets. The polarities or the *northness* and *southness* of a magnet, are not only related to each other, through or within the magnet itself, but they are also related externally to opposite polarities, (in the manner of static electric induction,) or they cannot exist; and this external relation involves and necessitates an exactly equal amount of the new opposite polarities to which those of the magnet are related. So that if the force of a magnet *a* is related to that of another magnet *b*, it cannot act on a third magnet *c* without being taken off from *b*, to an amount proportional to its action on *c*. The lines of magnetic force are shown by the moving wire to exist both within and outside of the magnet; also they are shown to be closed curves passing in one part of their course through the magnet; and the amount of those within the magnet at its equator is exactly equal in force to the amount in any section including the whole of those on the outside. The lines of force outside a magnet can be affected in their direction by the use of various media placed in their course. A magnet can in no way be procured having only one magnetism, or even the smallest excess of northness or southness one over the other. When the polarities of a magnet are not related externally to the forces of other magnets, then they are related to each other: *i. e.* the northness and southness of an isolated magnet are externally dependent on and sustained by each other. Now, all these facts, and many more, point to the existence of physical lines of force external to the magnets as well as within. They exist in curved as well as in straight lines; for if we conceive of an isolated straight bar magnet, or more especially of a round disk of steel magnetized regularly, so that its magnetic axis shall be in one diameter, it is evident that the polarities must be related to each other externally by curved lines of force: for no straight line can at the same time touch two points having northness and southness. Curved lines of force can, as I think, only consist with physical lines of force. The phenomena exhibited by the moving wire confirm the same conclusion. As the wire moves across the lines of force, a current of electricity passes or tends to pass through it, there being no such current before the wire is moved. The wire when quiescent has no such current, and when it moves it need not pass into places where the magnetic force is greater or less. It may travel in such a course that if a magnetic needle were carried through the same course it would be entirely unaffected magnetically, *i. e.*, it would be a matter of absolute indifference to the needle whether it were moving or still. Matters may be so arranged that the wire when still shall have the same diamagnetic force as the medium surrounding the magnet, and so in no way cause disturbance of the lines of force passing through both; and yet when the wire moves, a current of electricity shall be generated in it. The mere fact of motion

cannot have produced this current: there must have been a state or condition around the magnet and sustained by it, within the range of which the wire was placed; and this state shows the physical constitution of the lines of magnetic force. What this state is or upon what it depends cannot as yet be declared. It may depend upon the ether, as a ray of light does, and an association has already been shown between light and magnetism. It may depend upon a state of tension, or a state of vibration, or perhaps some other state analogous to the electric current, to which the magnetic forces are so intimately related. Whether it of necessity requires matter for its sustentation will depend upon what is understood by the term *matter*. If that is to be confined to ponderable or gravitating substances, then matter is not essential to the physical lines of magnetic force any more than to a ray of light or heat; but if in the assumption of an ether we admit it to be a species of matter, then the lines of force may depend upon some function of it. Experimentally mere space is magnetic; but then the idea of such mere space must include that of the ether, when one is talking on that belief; or if hereafter any other conception of the state or condition of space rise up, it must be admitted into the view of that, which just now in relation to experiment is called mere space. On the other hand, it is, I think, an ascertained fact, that ponderable matter is not essential to the existence of physical lines of magnetic force.—*Trans. Roy. Inst. June 11th, 1852.*

For the Journal of the Franklin Institute.

Speed of the Transatlantic Steamships, during the year 1852. By B. F. ISHERWOOD, Chief Eng. U. S. Navy.

Finding it necessary for my own information to know the fair average performances of the Atlantic steamships for the last year, I constructed the following tables, in which "the longest," "the shortest," and the "mean passage" are given, with the speed per hour in geographical miles of 6082 $\frac{2}{3}$ feet, at which the mean passage was made. The time of making the passage is the *true* time, not the apparent; 4 hours and 45 minutes being allowed as the difference between the American and British ports. The speed of the vessels per hour is calculated for the following distances, viz :

New York (battery) to Liverpool,		3084 geo. miles
Boston to Liverpool, via Halifax,		2883 "
New York to Cowes,		3120 "
New York to Glasgow,		3000 "
Philadelphia to Liverpool,		3250 "

In remarking the speeds of the screw vessels plying between Liverpool and Philadelphia, it must be borne in mind, that the time given, and from which the speed is computed, is from dock to dock; and that the latter city being situated on the Delaware river 110 miles from the ocean capes, obstructions are frequent in its navigation, from fogs, ice, narrowness of the channel, &c., causing occasional detentions, which being included in the time given, make the vessel's speed appear somewhat less than the truth. The steamers plying to New York and Boston suffer detentions from these causes in a less degree.