

THE SHEFFIELD STEEL MANUFACTURES.

Most of our workers in iron are familiar with the name of Thomas Firth & Sons, of Sheffield, England, whose tool steel bears such a high reputation in this country. Mr. Mark Firth, the head of the firm, is this year Mayor of Sheffield, and has signalized his term of office by presenting the people with a magnificent park, paying the whole expenses (over \$500,000) from his own pocket. The park was recently opened, with great rejoicing, by the Prince and Princess of Wales, who took an opportunity of inspecting several of the most remarkable of the steel works of the very grimy and very prosperous city.

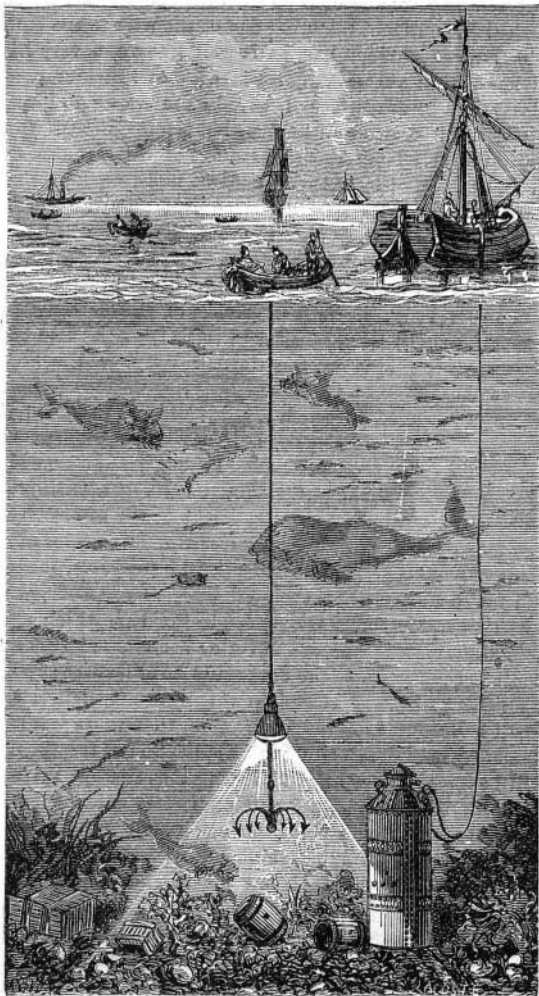
Our first engraving represents a scene in Messrs. Firth's works. An ingot for making the interior tube of an eighty tun gun is being cast, the gun, as we have already explained, consisting of a tube of fine steel surmounted by welded coils of wrought iron. The steel is melted in crucibles, which are brought to the founding pit on wheeled trucks, as shown in our engraving. By this means, ingots of nearly any weight and of the highest purity can be readily cast; and they are then forged into shape by immense steam hammers. We have frequently spoken of the large hammer, erected at Woolwich for welding the iron coils on these large cannon. This implement cost about \$250,000, and the falling portion weighs 40 tons, its force being increased by the use of steam to give it additional velocity. Messrs. Firth have recently erected a similar hammer in their works at Sheffield. But the greatest of all is being built at Krupp's works at Essen, where \$1,000,000 is being expended in building the largest hammer yet conceived, even in this age of Cyclopean wonders.

It is found that tubes for ordnance must be of pure steel, but softness of the metal is a requisite, a hard metal being too brittle to sustain the concussion of the large charges of powder used in these guns. The milder steel is tenacious, and has been proved to be almost indestructible by wear.

The Bessemer steel process is very largely carried on in Sheffield, the works of Sir John Brown & Co., Vickers & Co., and many others being largely in this manufacture. The second engraving on the opposite page represents the emptying of a Bessemer converter of its charge, after the metal has been brought to the required condition by the injection of the air blast. The proportion of carbon present in the metal is ascertained by the spectroscope, the moment for stopping the blast being ascertained by the use of that instrument with marvelous nicety.

DIVING BELL AND GRAPNEL.

We have already described M. Toselli's grapnel for raising heavy and valuable articles from the bed of the sea; and we now publish an engraving showing some recent improvements and new uses for this very ingenious apparatus. A diving bell, constructed of iron and bronze and weighing 3½ tons, is used; it is about 4 feet in diameter and 14 feet in height. The diver enters at the top, the lid on the dome being raised for the purpose, and the upper part is wholly out of the water when the bell floats, which gives an easy entrance to and exit from the apparatus, the bell not needing to be suspended by a crane. When the diver has entered the



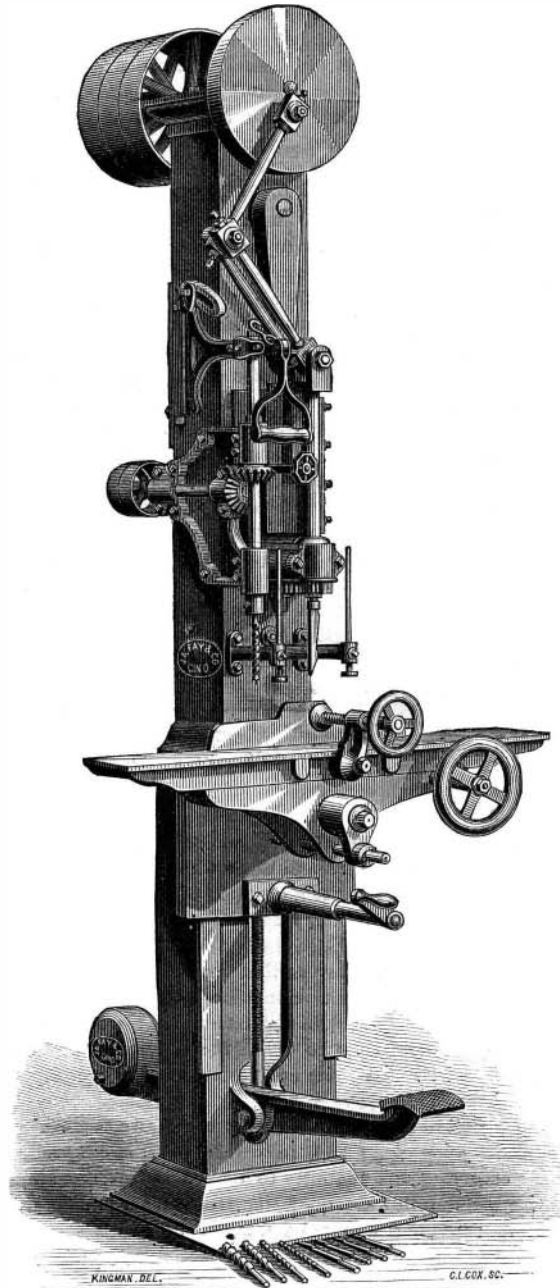
bell and closed the lid, he descends by allowing the water to enter the lower part of the cylinder, and he can come to the surface by ejecting the water by means of a pump placed inside the bell. Thus no rope or tackle is used, and the only necessary connection between the bell and the attendant boat is a telegraphic wire, shown in our engraving

At a distance of 5 feet from the bottom of the bell are placed bullseye glasses, guaranteed to resist a pressure of 60 atmospheres, equivalent to over 300 fathoms of water. At a depth of over 55 fathoms, the darkness is such that artificial light is necessary, both for taking observations and for directing the operations of the grapnel, which is provided with a submarine lamp. The bell is made double, the space between the circular walls being a magazine for fresh air; and two men can remain all day in the bell without further supply from above. Ample arrangements are made for absorbing the products of respiration.

The whole system seems to be complete and efficient, and in employment for coral, pearl, and sponge fishing, as well as for wrecking and salvage purposes, it will probably be found very valuable

J. A. FAY & CO.'S MORTISING AND BORING MACHINE.

The operation of mortising is one which has, to a large extent, engaged the attention of producers of woodworking machinery, and the numerous difficult problems in connection therewith have been solved only by actual experiment. Of the various systems in use for mortising in wood, the verti-



cally reciprocated chisel has obtained a preference. Other systems, such as rotating tools of various designs, are in use for special purposes where the same results could not be produced, or the stuff be conveniently handled, with the reciprocating mortising machine.

The class of work for which a machine of the abovementioned nature is wanted has a governing influence upon its construction. In one case the bed may have a vertical adjustment to receive the thrust of the chisel, which has a fixed distance to travel without any variation in its terminal points; and in another the bed may be in a fixed position, and the chisel be brought down from its highest position, where it has no reciprocating motion, to the depth of the mortise and full length of the stroke. An excellent example of the latter method, or variable stroke mortiser, is given in the accompanying illustration of a mortising and boring machine for agricultural, wagon, and cabinet work, recently brought out by the well known wood tool builders, J. A. Fay & Co., of Cincinnati, Ohio, who call it their No. 3½ mortising and boring machine.

This machine has for its support a cast iron column of strong section and substantial base. The driving shaft, carrying the pulleys and crank wheel, is placed at the top of the column, and revolves in self-oiling bearings with heavily bolted caps to receive the impact produced by the chisel blow. The treadle is connected by a rod to a short crank on the back end of the shaft to which the radial arm in front is keyed. This radial arm is connected with the central joint of the intersecting rods which connect the chisel stock with the pin in the crank wheel. By depressing the treadle, the radial arm is thrown out, which draws the central joint nearly into the vertical line drawn through the center of the dri-

ving shaft, and this produces the full stroke of the chisel with all the variations from a stationary position. There is attached to the short crank on the radial arm shaft a frictional slide, which receives the force of the stroke of the chisel, thus entirely relieving the foot of the operator from its effects.

The attached boring apparatus is set to the center line of the chisel, and will bore to the full depth of the mortise. It is driven from a pulley on the shaft at the top of the column, and has tight and loose pulleys so that it can be stopped while the chisel is operating. The bed is of a compound character; the timber can be moved upon it the length of the mortise, or the bed can be moved with the timber clamped to it, by means of a rack and pinion and hand wheel in front. There are stops for holding down the stuff, and necessary arrangements for adjusting to different sized mortises. The bed can be adjusted to any desired angle and mortises with the same facility as to a right angle.

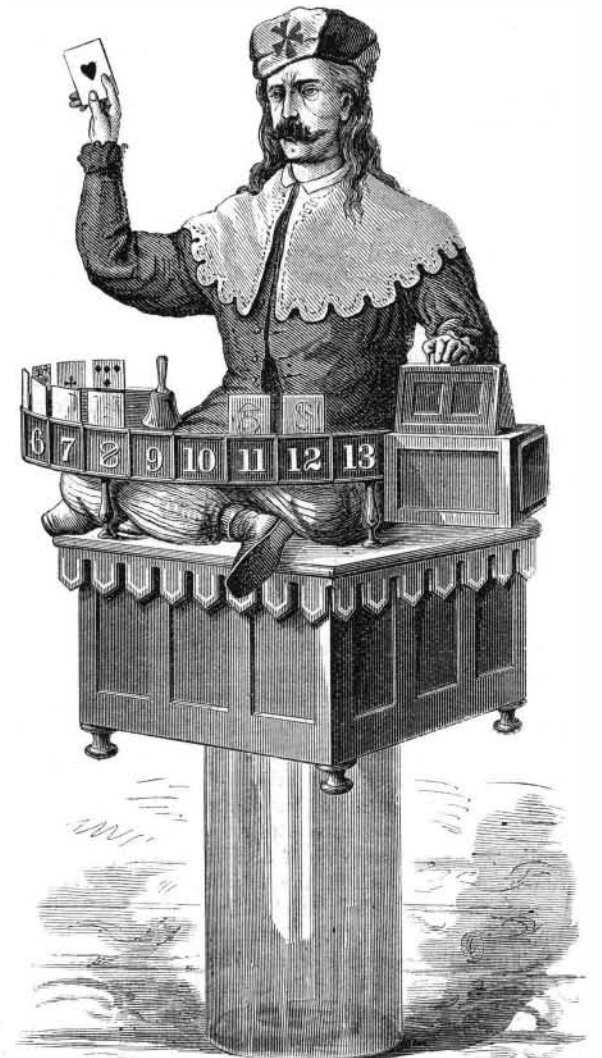
An important feature in this machine is the positive automatic reverser for the chisel, which is operated simultaneously with the raising of the chisel from the mortise. This being done at the end of the mortise, the chisel is thereby placed in position for finishing.

Further particulars can be obtained by addressing the manufacturers, J. A. Fay & Co., Cincinnati, Ohio.

THE PSYCHO MYSTERY.

We make the following extract from a letter to a gentleman in Boston, from Mr. J. A. Clarke, one of the inventors of the curious automaton Psycho, which of late has attracted much attention in London. Some time ago we mentioned this subject and noted the apparent discovery of the trick by an American gentleman, who suggested that the figure was worked by an air blast through the hollow glass pedestal. This suspicion was confirmed by one of the exhibitors declining to close the aperture previous to the operation of the automaton. It now appears that this test is freely permitted, so that the mystery of how the figure works remains as great as ever. We leave the (of course *ex parte*) statement of Mr. Clarke to the consideration of our readers without further comment, only reserving to ourselves the opinion that a solution to the puzzle certainly exists, and that that solution will be forthcoming should Messrs. Maskelyne and Cooke see fit to submit their trick, on this side of the Atlantic, to the crucial test of proverbial Yankee 'cuteness.

"Several years ago," says the writer, in substance, "it occurred to me that there was a good opening for a conjuring invention which should be really original and should baffle the profession as well as the public. After very many designs, I finally adopted the principle now embodied in Psycho, and I believe it is a completely new application. I made a rough model of the mode of working, and by accident was brought into communication with Mr. J. Neville Maskelyne. Mr. Maskelyne, possessing extraordinary ability in designing and constructing mechanical subtleties, has marvelously worked out my ideas; and Psycho is so much the fruit of mutual contrivance that all the parts may be said to be the



joint invention of us both. We designed an isolated figure, perfectly removed from any possible connection with anything or anybody outside, with no communication (mechanical, electrical, magnetic, pneumatic, hydraulic, or otherwise) conceivable from the stage, back, sides, roof, or elsewhere,

yet controlled by our influence, so that the figure moves when and in whatever manner desired."

To show diversity of effects, we make the figure calculate numbers and play whist. But it is adapted for many other things that we may choose to set it to; and it works precisely as if there were a person inside, and yet there is nothing beyond the mechanism. The audacious part of the invention is that a maker of automata, or other person, is allowed to see and feel all the inside of the figure, so as to satisfy all senses that there are no spaces concealed by optical arrangement or otherwise. The chief difficulty was in demonstrating to the public that the automaton is really insulated from all connection with the stage or with the performer: and it is sometimes exhibited in one way and sometimes in another. It is placed upon a hollow glass cylinder 24 inches in height, as shown in the engraving, or upon the carpet or upon a loose wooden stand, with legs to keep the automaton from the floor. Another way is that the glass cylinder is set loose upon a small wooden stool that is set loose upon another wooden stand, and the legs of the latter are set loose on glass pianoforte insulators.

The audience are at liberty to go upon the stage and handle and examine all the parts as much as they please, and anybody may remain close to it while it is in operation, and see and feel that no threads, or wires, or any other things connect any parts of the apparatus with the outside.

I should say that a single pillar, instead of a solid glass pillar or two glass pillars, was adopted, because a former invention worked by one piece of glass sliding or revolving inside another, while the appearance was that of a single solid piece; and to suspend Psycho by cords would suggest electricity.

Thus it will be seen that the arrangement precludes the theory of a Mr. Coffin, from America, who published an explanation representing that air is forced into or down out of the glass. If it were, how could it produce the great number of movements which Psycho performs? Besides, it will act just as well in any private room as on a public stage. It does not require any contrivance under or behind a stage which cannot be worked in a private room.

The figure sits upon a small box; the latter is much larger than it need have been, for we did not know how much space the mechanical movements would require. Were another box to be made it would be much more compact.

Psycho has worked twice a day (half an hour each time) since the middle of January last, and nothing has ever got out of order beyond the wearing of a few of the cords by which the counterpoise weights are suspended over a pulley.

As at present exhibited, the performance is as follows: The audience names two numbers, and Psycho multiplies them together and shows the answer (one figure at a time) by opening a little door in a small box and sliding the figure in front by a movement of its left hand. The audience give it a sum in division, and it shows the answer in the same manner. Then three persons go on the stage, inspect Psycho and the apparatus, and, sitting at a side table, play a game of whist. The thirteen cards for Psycho are placed, upright and singly, in a quadrant rack over the range of the figure's right hand. The arm has a radial motion horizontally to find any card wanted, and Psycho lifts the card and holds it up in view of the audience. It lifts the card up repeatedly, or keeps it up, at command of any person among the audience. The figure then covers the card to be played. Mr. Maskelyne then takes the card to the table, and calls out the names of the cards as the player plays them; and sometimes he retires from the figure and card table, to show that Psycho goes on with the game independently of the conductor. After the game, it tells, by movements of its arm, the state of the game and the number of tricks in its favor. Psycho shakes hands with the players, and answers questions by ringing a bell. It also takes part in some usual card tricks.

An infinite number of effects may be produced, but the above are sufficient to show in general what Psycho does."

He closes his letter by saying: "I hope this general description will enable my friends in America to understand and appreciate some of the merits of the automaton card player."

Correspondence.

The Electric Force and Magnetism.

To the Editor of the Scientific American:

On pages 229 and 260 of the current volume of the SCIENTIFIC AMERICAN, I observe that two of your readers take some exceptions to certain of my assertions in respect of terrestrial magnetism and the electric force. I cannot do better, in continuing the discussion of these interesting subjects, than reply in explanation and further elucidation.

There is every reason to believe that magnetism, so to speak, is a crystallization of the electric current.* This expression may at first glance strike the reader as somewhat singular; but after ten years of almost constant practical experiment in this branch of the science, I am unable to advance any more expressive or significant proposition than is compassed by this phrase. Electricity and magnetism are, as we know, interconvertible, and the great difficulty with electricians is to draw between them a distinguishing line; for, paradoxical though it may seem, while one is the other, there is so marked a dissimilarity that we cannot reasonably overlook the difference. With all deference to those who believe that my statement "that the earth is not a great magnet, but that the phenomena of the magnetic needle are due to the electric earth currents which flow at right angles to the earth's axis" is contradictory, because the earth, being

surrounded by such currents, is as much a magnet as the magnetic needle, I see no reason why the statement should be qualified. For these reasons, susceptible of easy proof:

That if the earth were a great magnet, the phenomena of the magnetic needle would not exist.

That even those scientists who accept the magnetic theory are forced to acknowledge that a very complex system of magnets indeed, in the earth's interior, instead of the earth being a great magnet, is necessary to account for the phenomena of the magnetic needle. (In a discussion of magnetism, we should obviously confine ourselves within distinguishing lines, otherwise we might confound the attraction of gravitation with magnetism. We have no right to formulate a generality, but should individualize details and branches.)

That it is impossible for the earth to be magnetized (I use the word in its distinctive sense) by the electric earth currents encircling it. The utmost that can be urged is that those portions of the earth's surface which are traversed by the electric currents are magnetic; but even this would be an erroneous hypothesis, for it is in the atomic action or condition alone that magnetism exists and is, and this atomic action is transferable to and through any matter whatever; and air, like a metal, is in this sense magnetic, for it serves merely as the conductor or medium for propagation of magnetism; to which conductor the magnetic force is confined, and which conductor, the same thus being the medium for the propagation of the force, obeys the action of the force, which is inseparable from the conductor, bound to it by those links which render the magnetic or electric force impossible without the conductor. If one desire illustration of this fact, he need only repeat the experiment of revolving a disk of a non-magnetic metal, such as copper, which a magnet does not attract, practically speaking, between the poles of a magnet. It may be heated in this manner to redness, the heat being produced by the resistance offered to the revolutions of the disk by the condition of the atomic particles of the space intervening between the poles of the magnet. Or he may seek for a solution of the magnetic effect, and he will find sufficient answer in the phenomenon which he will observe of a magnet drawing to itself a magnetic metal placed at some distance from it, which phenomenon is explainable alone upon the hypothesis that the atomic condition of the magnet is transferred to the intervening space and thence to the armature, the armature only being attracted, but the intervening space being the medium for the propagation of the magnetic force, which causes the magnet and armature to unite, just as a belt in a machine shop acts as the medium of transmission of the force which causes one pulley to follow the motions of another.

The electric force or the magnetic force is thus nothing in itself; it cannot exist without a so-called conductor; and as all substances are more or less conductors, we have clear proof that the electric force, which is nothing in itself, is merely a certain condition of the atomic particles of those substances. It will, upon close inspection, be found that the only difference between me and those who sustain the objection under review relates to a question of terms: while they combine, and thus confound, I have sought to separate phenomena, which, though intrinsically the same, are in reality separated by as wide a gulf as that which divides the sects in religion, or distinguishes attraction from repulsion, or a live man from a dead man, in the latter case the body being the same, dead or alive. To define the differences and present the same in terms plain and forcible is a purpose soon to be accomplished.

It is my design at present to reply especially to the communication upon page 260, in which your correspondent frankly confesses his inability to realize the circumstances set forth in the following quotation from a past communication by me: "When one pulls a bell cord, and instantaneously a bell is rung in a distant room by the molecular transmission over or through the bell wire of the force applied at the cord, does not one realize that he is as veritably, as wonderfully, and by a similar molecular motion transmitting it by applying a battery to a telegraph wire, and thus setting the atomic particles in motion?" Your correspondent acknowledges that in the case of the bell cord one can easily realize the disturbance of the atomic particles from ocular demonstration, but he adds: "In the case of the telegraph, he sees no motion, either where the force is applied or where it is taken off, even when the force so applied is very powerful." If I could have your correspondent on my premises for an hour, I am confident I could clear his mind of doubts by a few practical exhibitions; but as I shall probably never have that pleasure, I am constrained to resort to the example of argument and the logic of stated facts.

In the first place, he assuredly would not deny the verity of a proposition upon the ground that it is incapable of ocular demonstration. By so doing, he would deny the confirmed theories of the propagation of light, sound, and heat; for, taking an example, one can never have ocular demonstration that so many million light waves are necessary to produce a certain color, and so many another color, or that so many waves or vibrations of matter are necessary to produce a certain sound. Now I am enabled positively to assert that the propagation of the electric force is by molecular action, that the electric force is a certain active condition of the atomic particles of matter, for, unlike your correspondent, I have had ocular demonstration of this molecular action. It was not my design to allude to experiments I am now conducting until such time as I should be able to lay a mass of absolutely convincing facts before your readers, and I cannot even now enter into a statement which not only requires careful preparation, but would be premature, in view of the incompleteness of detail which would result from a

presentation previous to such time as that in which the necessary instruments can be prepared for observation and accurate measurements be taken. I could not undertake the task at present without injustice and risk to myself; but I can promise that a series of interesting and novel facts shall be forthcoming within the next two months which will for ever set at rest all conflicting theories in respect of the electric force. But leaving out of the question these new developments, I trust that I can satisfy your correspondent by other proof. He says: "The wire terminates in a coil, and inside of this coil, entirely separated from it, is a bar of metal, and entirely separated from this is the bell lever. Now it is difficult to conceive how the mere molecular disturbance of the wire causes a like disturbance in the bar, which again causes the same in the bell lever or armature. If the motion were transmitted directly to the bell lever by a material connection, as in the first case (the case of the bell wire and bell cord), then there would be no difficulty in understanding this application of the theory." It should be well known that magnetism is the result of induction, for it is a well settled fact, thus: that a current of electricity moving in the vicinity of a magnetic metal extends to that metal "tubes" (convenient term) of electric force which magnetize the metal. This fact is so well established that discussion is out of the question, and it is apparent that this can only be the case upon the hypothesis that the intervening space or substance partakes of the nature of the electric action of the conductor, by which means a transfer of force is effected; for it must be borne in mind that no substance whatever is a non-conductor of the electric force, the conductivity simply differing in degree in different substances. For this very reason a current of low tension, that is, a current which has not sufficient electro-motive force to leap a very short length of a poor conductor, such as wood or air, in preference to traversing a very long good conductor, will enable a telegraphic signal to be transmitted a proportionally greater distance than a current of greater electro-motive force, the maximum of which electro-motive force is secured in an induced current or in frictional electricity. Thus with a Grove or a carbon battery, the elements of which are of considerable proportions, a current may be transmitted from New York to Chicago, automatically, at the rate of twenty-five words per minute; but by reducing the size of the elements one half and doubling the number of elements, a speed of fifty or more words per minute may be obtained, because we have increased the electro-motive force of the current while decreasing its quantity, and the current has therefore greater tendency to leap the wire, that is to say, to follow a short poor conductor to the earth through wood, glass, or air, in preference to following a long good conductor for an immensely greater distance, thereby in great measure preventing that elongation of a signal, which is inimical to rapid transmission over a long circuit. But this merely illustrates the point, at which I wish to arrive, that any current of electricity whatever has its direct and inductive circuit, and that one pole only of a battery put to a wire will give a circuit, without regard to whether the other pole of the battery or the other end of the wire be connected to the earth, as can be demonstrated by sufficiently delicate instruments, markedly when the atmosphere is moist, the reason being that the atmosphere acts as a conductor from the other pole of the battery to the earth, and from the other end of the wire to the earth.

The induced current has, as is well known, a very high tension, so high that it may reach a point at which it will not traverse a hundred feet of wire in preference to leaping to earth, and it is also well known that the magnetism which actuates the bell lever is the resultant of this induced current. The effect of induction should be understood precisely the same as we understand imparted heat. For instance, if we bring a heated body near another, the heat will be imparted from the one to the other. In precisely the same manner, when we bring an electrified body into proximity with another body, the latter partakes of the electrification of the former. By what means? Precisely as the cold body partakes of the heat of the warmer body, or the warm partakes of the cold of the colder body, by means of the intervening substance, to which the atomic conditions of the heat and the cold are imparted. Your correspondent will doubtless now realize that what is termed insulation or isolation, in respect of the electric force, is really no insulation or isolation at all, but a poorer connection, the inferiority of which may be compensated by the electro-motive force of the current. Therefore, contrary to what he supposes, it is not "difficult to conceive how the mere molecular disturbance of the wire causes a like disturbance in the bar, which again causes the same in the bell lever or armature;" it is only difficult to conceive how the case could be otherwise; and, as Mr. Marckleysays, "if the motion were transmitted directly to the bell lever by a material connection, then there would be no difficulty in understanding this application of the theory," it will be apparent from the foregoing that there is the most direct material connection, the tubes of force extending from the coil to the bar, and from the magnetic bar to the armature, by means of the intervening substance, air or other.

Not only is this the fact, but the magnet and armature



may be dispensed with altogether, and your correspondent will be able to witness an ocular manifestation. Let him construct a circuit as shown in the engraving.

* Electric current, like electric potential, will some day be positively defined—a convenient term."