SCIENCE IN TOYS.

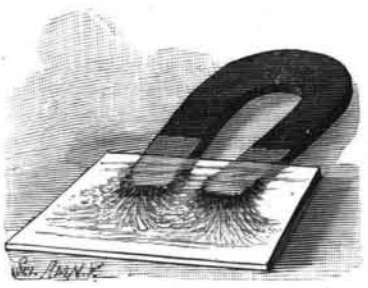
VI.

In view of the comparatively recent advance in electrical science, it is remarkable that so little attention has been paid to electrical and magnetic toys. Enough, however, has been done in this direction to furnish material for a great deal of study and experiment.

A common, simple, and, at the same time, wonderful toy is the permanent magnet. Faraday made it the subject of investigation and study, and it is to his skill as an investigator that we owe the great discovery of induction, which has made all modern electrical enterprises possible. Faraday reasoned, that since the circulation of an electric current in a wire coil surrounding a bar of steel rendered the bar magnetic, the introduction of a magnetic bar of steel into a coil of wire should produce an electric current in the coil. Experiment proved the reasoning correct, and the world is richer for the discovery of induction.

A magnetic bar of steel will attract and repel. Its influence reaches out to a distance, rendering other objects within its field magnetic. The very fact of holding its armature with such tenacity always excites wonder, even in those who know most about it.

The direction taken by the lines of force emanating from the poles of the magnet may be exhibited by the old and well known experiment, consisting in sprinkling iron filings over a glass plate laid over the poles of the magnet, as shown in the engraving.



MAGNETIC CURVES.

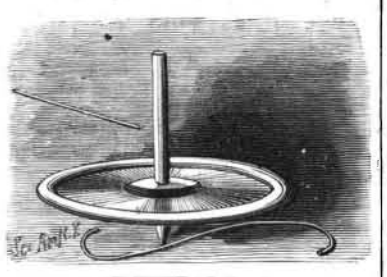
These curves show where the field is strongest.

The rolling armature applied to a long U-magnet exhibits the persistency with which an armature adheres to a magnet. The wheel on the cylindric armature acquires momentum in rolling down the arms of the magnet, which carries it across the polar extremities and up the other side.

A very pretty modification of this toy has recently been devised. It consists of a top with a magnetic spindle, and straight and curved iron wires. The top is spun by the thumb and fingers, in the usual way, and one of the wires is placed against the side of the point of the spindle. The friction of the spindle causes the wire to shoot back and forth with a very curious shuttle motion. The point of the top rolls first along one side of the wire and then along the other side.

MAGNET AND ROLLING ARMATURE.

The ordinary magnetic fish, ducks, geese, boats, etc., are examples of floating magnets, which show in a very pleasing way the attraction and repulsion of the magnet. The little bar magnet accompanying the magnetic figures serves as a wand for assembling or dispersing the floating figures; or it may serve, in the hands of the juvenile experimenter, as a baited fish hook.



MAGNETIC TOP.

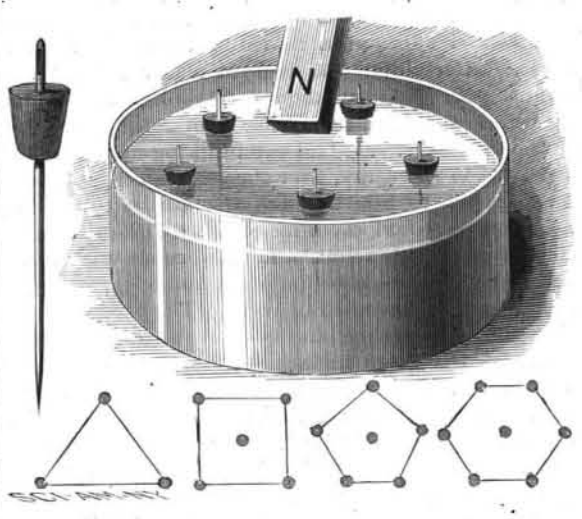
FLOATING MAGNETIC FIGURES.

Prof. A. M. Mayer has devised an arrangement of floating magnetic needles which beautifully exhibits the mutual repulsion of similarly magnetized bodies. A number of strongly magnetized carpet needles are inserted in small corks, as shown in the perspective view of the engraving.

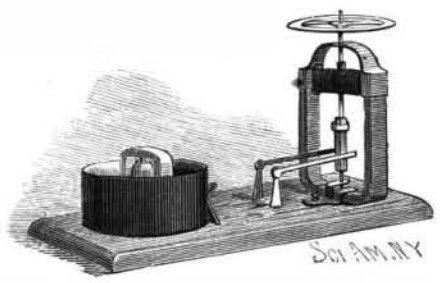
When floated, these needles arrange themselves in symmetrical groups, the forms of the groups varying with the number of needles.

One pole of a bar magnet held over the center of a vessel containing the floating needles will disperse the needles, while the other pole will draw them together.

A fifty-cent electric motor is perhaps quite as remarkable as a steam engine of the same price. Such a motor is shown in the annexed engraving. It embodies all the essential features of the larger motors and electric generators.



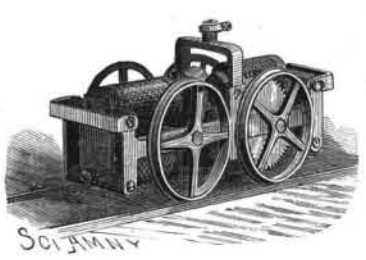
MAYER'S FLOATING NEEDLES.



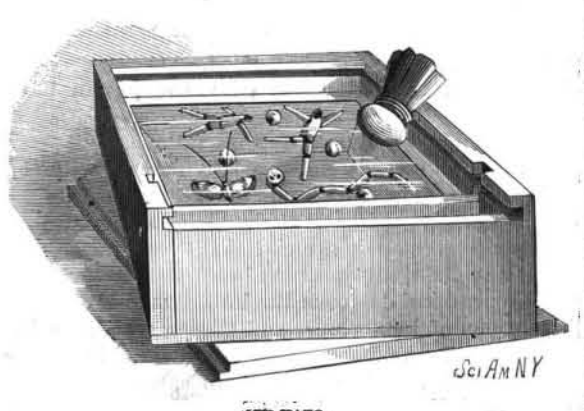
FIFTY CENT ELECTRIC MOTOR.

The vertical spindle which carries the armature is journaled at the lower end in the middle of a U-magnet and at the upper end in a brass cross piece attached to the poles of the magnet. The armature consists of a cross arm of soft iron wound with four or five layers of fine wire. The terminals of the winding of the armature are connected with a two-part commutator carried by the spindle, and touched by two commutator springs supported by wires driven into the base. A metal stud, rising from the base, is connected with one of the commutator springs, and is provided with an insulating covering on its sides, while its upper end is bare. Upon the stud is placed an annular cell of carbon, which is touched on its outer surface by a spring connected with the remaining commutator spring. The cell forms one of the elements of the battery. The other element consists of a bar of zinc provided with a central aperture for receiving the upper end of the stud, and having its ends bent downward. The cell is filled with a solution of bisulphate of mercury in water. As the salt is reduced by chemical action, a current is produced which will run the motor at a high rate of speed. The motor is fitted with a wheel or plate for carrying color disks, similar to those accompanying the well known chameleon top.

The toy electric locomotive is a far more expensive affair. It is provided with two electro-magnets with their poles facing each other. Between the poles of the magnets is placed a shaft carrying an armature having a number of arms. Upon the armature shaft is placed a star-shaped commutator, which interrupts the circuit for every revolution as many times as there are arms in the armature. The armature shaft carries a pinion, which meshes into a spur wheel on the drive wheel shaft. The wheels on one side of the locomotive are insulated, and provided with sleeves touched by springs, which convey the current to the commutator. The current passes from the magnets through the locomotive frame and drive wheels at the opposite side.



ELECTRIC LOCOMOTIVE.



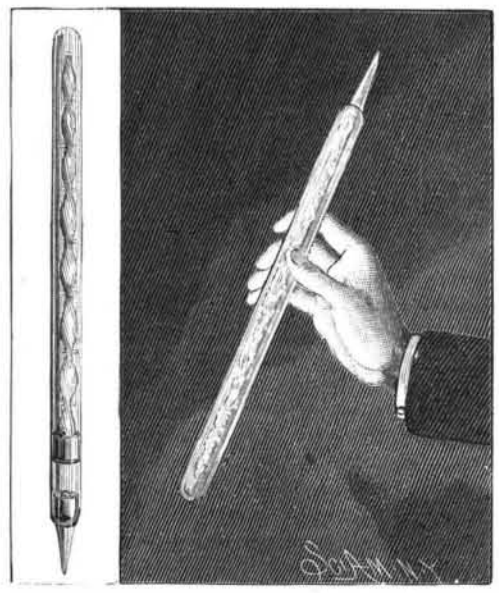
ANO-KATO.

The poles of the battery are connected with the track rails. The machine will run in either direction.

A toy exhibiting some of the phenomena of statical electricity is shown in the annexed cut. It has received the name of ano-kato, but it is only a simple electrophorus formed of a flaring box lined with tin foil, covered with a piece of ordinary window glass, and containing figures made of pith.

By rubbing the glass with a leather pad charged with a little bisulphide of tin, the electrical equilibrium is disturbed, and the figures are made to go through all sorts of gymnastics.

The self-exciting Geisslertube is a beautiful object in a dark room. The electrical effect is produced by the friction of mercury on the inner surfaces of the vacuous glass tube, as the tube is inverted or shaken. The tube is ingeniously contrived to prevent breakage by the falling of the mercury against the end of the tube, and at the same time to increase the effectiveness of the device by arranging two tubes concentrically, the inner tube being beaded, and provided with little knobs for breaking the fall of the mercury. The inner tube is sealed to the outer tube near one end, and in the inner tube, a short distance above this sealing, is formed an aperture which determines the amount of mercury to be retained between the inner and outer tubes when the tube is inverted preparatory to use, as all of the mercury between the two tubes and above the aperture will run through the aperture into the lower end of the tube. In this manner the mercury is equally divided, so that when the tube is reversed, one half of the mercury flows through the inner tube, and the other half flows downward between the inner and outer tubes.



SELF-EXCITING GEISSLER TUBE.

The full effect is realized only when the mercury is allowed to flow quickly from one end of the tube to the other, but any agitation of the mercury in the tube produces some phosphorescent light. G. M. H.

English Railway Couplings.

On the 2d of December last a number of tests were made at Derby with the prize car couplings shown at Nine Elms in March of last year, through the offer of a prize, the object of which is to prevent the present loss of life among car couplers. The contrivance which at the last demonstration elicited the most unanimous approval is a light pole, about 5 ft. 6 in. in length, with a skillfully devised hook at the end, by which the chains can be attached or set free in wonderfully short time. One man ran along twenty cars and uncoupled them in seventy seconds; another coupled them again in seventy-six seconds. This plan has been in use on the Midland Company's system for some time, and has led to a decided diminution of accidents. It is to be hoped, says the *Lancet*, that other railway companies will speedily take steps to terminate or materially diminish the slaughter which annually results from the goods guards and shunters having to pass between the cars to couple and uncouple them.

To Americans this mode of coupling cars is so clumsy as to be laughable; but it suits John Bull to a dot.

The Medical Possibilities of Photography.

The *Evening Post* says: "In the *Camera* magazine a very curious phenomenon, in connection with photography, is recorded by the person who observed it. He took a portrait of a child apparently in full health and with a clear skin. The negative picture showed the face to be thickly covered with an eruption. Three days afterward the child was covered with spots due to prickly heat. 'The camera had seen and photographed the eruption three days before it was visible to the eye.' Another case of a somewhat similar kind is also recorded, where a child showed spots on his portrait which were invisible on his face a fortnight previous to an attack of smallpox. It is suggested that these cases might point to a new method of medical diagnosis."

A Reporter's Visit to the Boston Telephone Exchange.

Any one who has often used the telephone must have had occasion to be impressed with the mysteriousness, the sense of material non-existence, of that part of the machine and its belongings that lies beyond one's own instrument and that of the person at the other end, whom one is talking to, says a writer in the Boston *Post*. My own material existence I am reasonably assured of. I can imagine my friend at the other end of the line. But between us two there is an airy nowhere, inhabited by voices and nothing else—Helloland, I should call it. The vocal inhabitants of this strange region have an amazing vanishing quality. Even while you are talking casually with one or another of them, you may become aware that you have been unaccountably "cut off;" and if you become impatient, and raise your voice in earnest demand or protest, the more you bellow, the more you become aware that you are idiotically shouting yourself black in the face against a mere inanimate box stuck against the wall. Nothing else than the supremest invention of the nineteenth century could make man so supremely ridiculous as he is when he is shouting objurgations into a telephone transmitter that isn't "connected." The consciousness of such an experience produces in sensitive men, I am sure, a sensation of nervous shock, somewhat akin to seasickness. And sometimes, when you are talking blithely enough through your central office intermediary, you hear the confused murmur of a hundred voices. You catch more expressions from private conversations than your nerves can transmit to the central office of your brain; and if you are imaginative you may undergo, as I have, a feeling as if you had a hundred astral bodies that were guiltily listening at as many keyholes. The central office is not like any other business establishment whatsoever. The telephone seems to you to have no visible agency. If you have business with the company, you telephone it. Your applications and complaints go over the wire to that one impersonal, impalpable voice.

In the first place, there is something besides a voice at the central office. I beheld, as the door was opened, twenty comely young women sitting in a long row, in easy arm chairs, before tables with endless apparatus before them. That was the first fact that I grasped. The next one was that those girls were not shouting at all. There was a low, indistinct murmur, and that was all. As I approached nearer I could hear, in tones not much above a whisper, the ever monotonous "Hello! hello!" "Ye-es!" "Good-by!" but one clear voice in a good speaking tone might have been heard plainly across that whole room above all the business of making the connections for 2,000 people. Every girl had strapped upon her head, or rather held there by its own grip, an apparatus composed of crossed steel bands, which held a small telephone receiver to her ear. Before her, dangling by a long wire in just such position as to hang exactly in front of her mouth, was the transmitter. Each girl leaned back in a comfortable attitude, and seemed entirely cool and totally unconcerned, while both of her hands were occupied in inserting wires with metal plugs at their ends into certain holes before her, and pulling them out again. There were rows upon rows of these little apertures, and every one of them represented somebody's telephone number. Each girl takes care of a limited number of calls, which are signaled to her by the dropping of a little metallic tablet with the number of the caller's instrument upon it; but she has within her reach, in those little apertures that I have mentioned, every one of the telephone numbers within the radius of the exchange.

"These seem to be young women of excellent physique," I said to the superintendent.

"We insist upon that," said he. "We have found that girls of good physique, healthy young women, are much less liable to irritation and impatience, much less likely to 'get rattled,' than those who are a little weak or ill. It is not that the work wears upon them, so that only women of unusual physique can stand it, but that we must have operators who are likely to keep their tempers and maintain coolness of demeanor. Does it deafen them? I have never known but one case of an operative's hearing being affected, and that might easily have been from some other cause. They do not seem to suffer much nervously, though there was one case of hysteria here last week. One of the girls—that one with the slender figure and dark hair near the end of the line—got confused and 'rattled,' as we call it, over a series of vexations, and asked to have a substitute placed in her chair. You see that we keep five substitutes in the room to relieve those who desire to be relieved at any time. Well, this young woman went into the girl's waiting room and had an attack of hysteria there. Not infrequently something occurs on the line—somebody gets impatient and loses his temper—which troubles the girls. They generally go out into their room and have a good cry, and come back feeling better. They certainly seem to like the work, though the pay is only $7 a week. The hours are not long; they sit all day; they are relieved when it is needful, and the actual work seems to be agreeable to them."

There was a strumming sound under the superintendent's table. He held a telephone receiver to his ear, and talked through a movable transmitter on the table. "Certainly," he said in a low voice, "I will relieve you." He summoned a young woman from the window, and motioned her to take the chair of one of the operators. He had been talking with one of the girls, not 15 feet away, over the telephone! She could have spoken to him through the air by turning her head, but it would have made a little bit of noise and confusion in the room, and this modern tower of Babel, this vocal sensorium of a whole city, is as quiet as a public library reading room. The substitute girl took the other's place, and two "calls" came tumbling down at the same instant, and somebody was undoubtedly vexed because he was not answered for an instant while she was making the other connections. But it takes but an instant.

"We like to have people who have telephones come up here," said the superintendent. "It gives them an idea how the thing is done, and we notice that they seldom get impatient in the use of their telephones afterward."

Certainly these girls were not trifling with their work. The superintendent, by merely putting an instrument to his ear, can hear every word that passes between an operator and the people with whom she talks; and that seems almost an unnecessary restraint. Vexation makes the work harder for the operator, and she avoids it. Women are found to be better operators than boys, though boys must be employed at night; and that is why the day service is better than that of the night.

The girls glanced at me as I walked by their desks with the passing curiosity of all women and all men, but their hellos went on just the same. I saw more than one genuinely pretty face. Helloland is not so ghostly after all!

Submarine Boats.

Submarine boats are a much older invention than is generally conceived; but they are now coming prominently forward, because there is a useful field for their employment, and also because modern devices have rendered it possible to construct vessels which can be propelled safely beneath the surface of the water. Who first suggested the idea is not known; but it seems well authenticated that in the reign of James I., a Dutchman named Drebbel designed a boat which was actually propelled by twelve oars under the surface of the Thames, the air being revivified by some liquor, the composition of which Drebbel kept a secret.

The Marquis of Worcester, in his "Century of Inventions" (1663), refers to a similar invention, and there is a record that a man named Day sank with his submarine boat in Plymouth Sound in 1774. It is, however, to Robert Fulton that we are indebted for the first definite ideas on the subject, for so long ago as 1801 he descended to a depth of 25 feet in the harbor of Brest, and demonstrated the fact that his "plunging boat" could be trusted to take himself and three companions under the water and return to the surface in safety. This boat was named the Nautilus, and when beneath the surface was moved 500 yards in about seven minutes, by two men turning the "engine," while Fulton regulated the position of the boat. On one occasion the boat remained beneath the surface for nearly six hours; but nothing in the shape of effective warfare was accomplished when Fulton was persuaded to lend his services to this country, though he did by way of experiment blow up some old vessels with torpedoes. Fulton published his work on the subject, "Torpedo War and Submarine Explosions," in 1810, at New York, in which he shows that a system of harbor defense based on stationary and movable torpedoes is the surest, quickest, and cheapest plan for protecting maritime cities against the naval forces of an enemy.

In 1860 a submarine boat was made in France, in which compressed air was utilized for working the propelling device, and also for expelling the water taken in to produce submergence; but this vessel, too, does not seem to have been a success. A submarine boat has, however, been used for some time by the Pacific Pearl Company in carrying out their fishing operations; but it is not intended to serve as a torpedo boat, being flat bottomed, with "doors" in the bottom, through which the oysters can be collected. Toselli's submarine exploring vessel is a fairly perfect device for diving, but has no means of propulsion; it is, in fact, an elongated diving bell, with reservoirs of compressed air and two or three stories.

Much attention has been devoted to the subject of submarine vessels in Russia, and many experiments were made in that country about twenty years ago; but no practical device of the kind was produced. The inventions of Denayrouse and Fleuss, which disclosed a method of carrying sufficient air to enable a man to breathe either in the ways of an exploded coal mine or beneath the water, gave an impetus to the search for a submarine boat, and modern inventions in connection with electricity have helped to place the scheme on the road to ultimate success. A few years ago two submarine boats were built at Liverpool from designs by Mr. Garrett, who employed chemicals to revivify the air and render it respirable over and over again; but the most successful of these boats was lost off the Welsh coast. Since then Mr. Nordenfelt has turned his attention to the subject, and has lately demonstrated that boats can be propelled for a few hours under water, although not with sufficient accuracy for torpedo work. A large and powerful vessel is being built from his designs, and will probably be ready for trial in the spring. Meantime Professor Tuck is progressing with the Peacemaker, which we briefly described, and which has since been astonishing those who have witnessed her performances in the Hudson River.

Both Nordenfelt and Tuck employ steam for driving the propeller, the former carrying the heated water in reservoirs, the latter using the Honigmann caustic soda (or potash) boiler. Recently, further trials were made with the modern Nautilus in the Tilbury Docks. That is a cigar-shaped vessel, 60 feet long by 8 feet in diameter. with a short raised deck in the center, through which a conning tower projects, and provides access to the interior.

The vessel is built of steel plates five-sixteenths inch thick, with 3 by 3 by ½ inch frames 1 foot 9 inches apart, and is estimated to be strong enough to withstand the pressure of 50 feet of water. The boat is fitted with two screws, each driven by an Edison-Hopkinson motor at about 750 revolutions, the current being supplied by 104 secondary cells; but owing to the comparatively confined space of the dock, no trials of speed were made. The method of sinking and raising the vessel was designed by Mr. A. Campbell, and consists in a simple method of decreasing or increasing the displacement without affecting the weight of the vessel. This is accomplished by means of four horizontal cylinders on each side of the hull, which can be thrust outward into the water or drawn into the hull.

The cylinders work through water-tight sleeves, and can be moved either by hand or by screws worked by gearing from a shaft so arranged that corresponding cylinders on each side are pushed out or withdrawn simultaneously. It will be readily understood that if the vessel with water ballast tanks full and the cylinders within the shell sinks to the bottom, the extra displacement which can be obtained by thrusting out the cylinders will bring her to the surface, while the tanks will enable her weight and trim to be regulated. Besides a rudder of ordinary pattern, the Nautilus has a horizontal fin or rudder for guiding the vessel or preventing a tendency to rise or dive, thus keeping a uniform depth below the surface.

It is said that the air contained within the vessel is sufficient for a two hours' submarine trip with a crew of six; but no doubt if other vessels of the kind are constructed, either compressed air will be carried, or some means will be adopted for revivifying the air, as men engaged in such work as submarine torpedo warfare will need clear heads, and must run no risk from air heavily charged with carbonic acid. A patent has recently been secured in this country by Mr. C. D. Goubet, of Paris, for a submarine torpedo boat in which equilibrium is maintained by a pendulum acting through a horizontal bar on a clutch that actuates one portion of a double action pump, which displaces water from one or the other of two reservoirs at the ends of the vessel. Water ballast tanks assist in the submergence of the boat, and the motor is driven by electricity supplied from storage batteries.

The screw propeller is movable, so as to be capable of giving the vessel an oblique direction in any sense in relation to the vessel's axis while having a regular continuous rotary motion. The vessel can thus be guided without a rudder, and can perform various evolutions. The torpedo is placed at the after part of the vessel, and is connected to an insulated wire wound on a drum. The crew enter an opening at the top closed by a dome, and sit on a compressed air reservoir from which air is taken and moistened by being caused to pass into the water compartments, whence it is discharged by a pipe into the dome. The vitiated air is constantly expelled by an air pump.

The torpedo vessel is fitted in front with a cutter or spike which can be projected forward several feet; it is worked by a lever, and serves to cut torpedo wires or nets. An obturator tube serves to discharge signal cartridges, which on reaching the surface explode, and thereby give an indication to the ship with which the torpedo vessel is connected. A special arrangement enables this vessel to be propelled also by means of oars. We are not aware that any trials have been made with this vessel, or whether one has been constructed; but we may rest assured that it is only one of many patents which will be taken out for vessels and machines adapted to submarine navigation for the purposes of warfare.—*English Mechanic.*

M. HIGNETTE makes a white artificial stone from sand which has been used for polishing plate glass.