SCIENTIFIC AMERICAN SUPPLEMENT No. 608

Scientific American Supplement, Vol. XXIV., No. 608. Scientific American, established 1845.

NEW YORK, AUGUST 27, 1887.

Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.

A REACTION PROPELLER.

On the 16th of December, 1886, a fearful accident stirred up the population of Asnieres and its surroundings. The motor of a whale boat exploded on the Seine a little below the Clichy bridge, the frail boat was blown in pieces, and the three persons who were in it were thrown into the water. Two of these were immediately killed, and the third, although wounded and badly burned in the face and hands, managed to reach the shore by swimming.

During the course of the pleadings that a lawsuit gave rise to, a little light was shed upon the affair. It was learned that the apparatus which had blown up was the fruit of an invention made by Messrs. Just Buisson & A. Ciurcu, the subject of which was a new mode of locomotion; and, further, that the principle of the apparatus was based upon the recoil that occurs in firearms. But from there to knowing the details of the invention, the distance was great, so we have refrained from speaking of it before ascertaining the exact cause of the accident. We thought that the best way to learn this would be to address Mr. Alexander Ciurcu, one of the inventors of the affair, and ask him for such details of the invention as he might conveniently be able to furnish. But after his trial and acquittal, Mr. Ciurcu had left France momentarily to return to his native country, Roumania. Having just returned from Bucharest and resumed the experiments at Asnieres that he was performing with his unfortunate friend, he has, in compliance with our request, given us a complete narrative, from which we glean the passages that follow.

Our propeller, says Mr. Ciurcu, is based upon the principle of reaction. Just Buisson first conceived the idea of utilizing it in propulsion, and I helped him put his idea in practice. It has been said that we utilize the principle of the recoil that occurs in firearms.

That is true; but the eolipyle invented by Heron of Alexandria might just as well have been given as an example, and for a still more striking one we have only to turn to the sky-rocket. The principle, which is as old as the world, is in all cases the same; it is the application as well as the means that are new.

When Mr. Maurouard, director of the division of powder and saltpeter to the minister of war, spoke the first time of our invention to the minister, and gave an account of the experiment that he had witnessed, and that had fully succeeded, he gave about this description, which sufficiently well summarizes the principle of it:

"Imagine a large rocket fixed horizontally in the rear of a vehicle, boat, or car of a balloon, in such a way that the gases produced by the slow combustion of the powder may escape freely into the air from behind. Further, suppose the rocket is inclosed in a cannon. When the rocket is once lighted, the gases will escape with force from the mouth of the cannon and produce in the interior of the latter a reaction that will tend to make the cannon recoil in a direction diametrically opposite to the projection of the gases. As the cannon is, for example, fixed to a boat, the recoil is transmitted to the latter, and the boat will move forward on the water through the sole force of the reaction of the gases. No purchase is taken upon the water, the boat having no wheels, oars, or helix. Instead of a cannon, the inventors had on their boat a sort of receiver of cylindrical form, in which they burned a composition that they said was of their inventing, and the properties of which were to fuse in a closed vessel and produce a large quantity of gas without leaving any solid residuum. In the back of this receiver there was an orifice designed for the escape of the gases that produce the reaction, and the section of this orifice could be varied at will by means of a valve maneuvered by hand. As the pressure gauge on the receiver showed the internal pressure, the latter could be diminished or increased by maneuvering the valve, and consequently allowing more or less gas to escape. The gas, on escaping with force, produced a loud noise, and the boat shot forward in a direction contrary to that of the projection of the gas in a regular and continuous manner. . . . The inventors thus ascended the current of the Seine with their boat for twelve or fifteen minutes, that is to say, until the combustible in the receiver was entirely consumed."

The reason that I have here introduced the person of Mr. Maurouard is because his competency in this matter is very great, and because he was witness of an experiment that was a perfect success.

The new method may be understood from what precedes. It is simply the direct propulsion effected through the reaction of gases at a high tension escaping into the air from a vessel in which they are produced by the combustion of a fusible substance.

Our starting point is to be referred to this principle of physics and mechanics: "A fluid inclosed in a vessel exerts upon the sides of the latter in every direction equal and contrary pressures."

Let us suppose that such fluid is a gas at a high tension. It is evident that as the pressures are equal and contrary they will mutually destroy each other, and this equilibrium of the forces causes the vessel to remain immovable. But if an aperture be made in one of the sides of the vessel, the gas will escape therefrom with force, and, as it will continue to exert the same pressure upon the internal surface opposite the aperture, such pressure being no longer balanced, the vessel will be thrust in the direction opposite to the projection of the gas. If the vessel is movable and the pressure is strong enough to overcome the resistances, the vessel will recoil as long as the tension of the gas will permit it.

Now that I have made known the physical and mechanical principle forming the basis and the starting point of our invention, I desire to speak of the invention itself. The great number of experiments and tentatives of all kinds made for several years with the object of applying the principle to a practical propeller I pass over in silence. I shall only say that we discarded steam, compressed air, and compressed powder for various reasons that I shall explain on another occasion. The question with us was to obtain a substance which, under a relatively small volume, should be capable, in burning, of furnishing us with a considerable quantity of gas, and which, while being but slightly inflammable, should be capable of burning in a closed vessel without being fed by the oxygen of the air, and should, on fusing, leave little or no solid residue. The rest did not inquiet us, for the studies that we had made, as well as common sense, assured us that, with such a substance, the propeller of our dreams would easily become a reality. Now, this combustible that we finally discovered is a mixture of several materials, and fulfills all the conditions that we required of it. It is easily manufactured and does not cost much.

After numerous experiments on land, having made ourselves certain that we could regulate at will the pressure of the gases produced by the combustion of our fusing substance, and that we could at any moment reduce any pressure to nothing, either by completely opening the orifice of reaction (whose total section was purposely exaggerated) or by allowing the gases to escape through lateral tubes, we tried the experiment upon water, and maneuvered a boat on the Seine simply through the force of reaction of gases.

Although our calculations, as well as the experiments made upon land by means of a dynamometer, left no doubt as to the possibility of maneuvering a boat on the Seine with our apparatus, our emotion and joy were great when, on the morning of the third of August, 1886, we for the first time ascended the current of the Seine with our "reaction propeller." We shot over the water, the shore appeared to fly behind us, and yet it seemed to us that we were indulging in a beautiful dream only.

From August 3 to December 16—the day of the terrible accident—we did not cease to make experiments on the water, and all of them demonstrated to us the value of our discovery.

Fig. 1.—BUISSON & CIURCU'S REACTION PROPELLER.

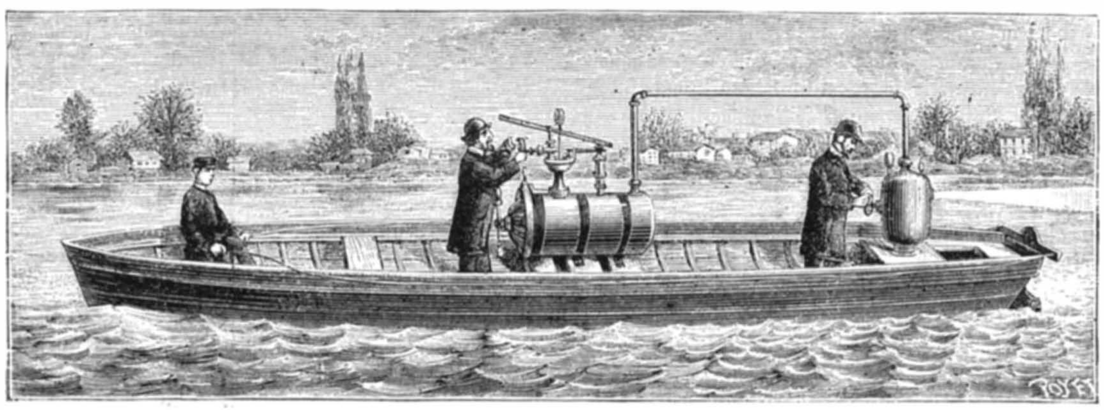


Fig. 2.—SECOND ARRANGEMENT OF THE PROPELLER.

Fig. 3.—EXPLOSION OF THE APPARATUS.

A REACTION PROPELLER.

In order to judge of these experiments, it is only necessary to glance at Figs. 1 and 2. The first of these shows us a six-oared boat, twenty-five feet in length, the sole motor of which is a small bronze pot of about three gallons capacity, and 20 inches in height and 12 in diameter. This pot is provided beneath with a pivot that turns in a wooden support. Handles fitted to each side of the support permit two men to lift the machine, in order to transfer it from one boat to another and to put it away after each trip. It is consequently entirely independent of the boat that it is to propel. Before we had a boat of our own, we made our experiments with the first one that we came across, and that we hired for an hour or two. We introduced our combustible (from 33 to 44 lb.) through the tubulure seen on the side near the engine man; then we fired up, and closed the aperture with a cork. On the side opposite this aperture is the orifice through which the gases escape that are to produce the reaction. We shall call this the reaction orifice. To this orifice is fitted a valve that permits of opening and closing it through a lever. As soon as the combustible was lighted, just so soon could we start, for it was merely necessary to reduce the reaction orifice in order to get up an internal pressure immediately—and when we say pressure we say force. The compressed gases escaped into the air with their characteristic noise, and produced on the inner side of the pot opposite their place of exit the reaction that shot us forward. With a charge of 33 lb. of combustible, we moved forward thus for a quarter of an hour under a pressure of between 10 and 15 atmospheres. To terminate the description of Fig. 1, I shall add that there were two lateral tubes beneath the charging tubulure, and these were designed to allow of the escape of the gas when occasion required it. They were put in communication with the pot by means of a cock. On account of their length, the gas escaping from them could not discommode the engine man. We called them discharge tubes. Our machine was provided also with a pressure gauge and safety valve. This was all. We made numerous trips on the Seine with this propeller.

I now come to Fig. 2. From the description of Fig. 1, it has been seen that with this apparatus it was possible to travel only as long as the combustion of the charge lasted. After the charge had been consumed, had it been desired to continue the experiment, it would have been necessary to stop and lose time in recharging the pot. So this first apparatus had no other end than to allow us to make a scientific demonstration of our discovery. For our final apparatus, designed for making long trips upon land and water, and in the air—especially in the latter, since that was the real object of all our efforts—we devised a complete system, permitting of traveling for a long time without interruption. Fig. 2 shows us, though incompletely, one of the means of carrying out such an idea. But this apparatus was not the final one, either. It, too, was to serve merely as a scientific demonstration. With it, we desired to offer a proof—a proof on a small scale—that we could move forward uninterruptedly. Moreover, this apparatus was to afford two other advantages—the capability of running with greater speed, and making a charge last longer.

As may be seen from the figure, we now had two cylinders. The larger of these, placed horizontally, served as a generator, and the smaller and vertical one as a gas reservoir, or, if it be preferred, as a motor. This latter was nothing else than our bronze pot of Fig. 1. We had slightly modified it, however, and this modification was fatal to us, for it was one of the causes of the catastrophe of December 16. Instead of keeping the movable disk of the valve on the outside, and maneuvering it by means of an external lever, as we had done until then, we placed it inside. It terminated in a steel rod that traversed the pot and passed through a stuffing box set into the old charging tubulure. At its extremity the rod received a hand-wheel, designed for actuating the valve. The latter was opened and closed by giving the wheel a quarter turn to the right or left. What happened will be seen further along. The generator was a simple steel plate cylinder, having a door that could be quickly opened. It was three feet in length and 16 inches in diameter. The thickness of the plate was 0·27 inch. In addition to a pressure gauge and safety valve, the generator was provided with two discharge tubes. A very strong tube, twice bent at right angles, established a communication between the generator and motor. The charges of combustible were prepared in advance in two reservoirs in the form of a half-cylinder that could be quickly and easily introduced into the generator by pushing them on slides within the latter.

The maneuvering can be readily understood; it consisted in introducing the reservoir full of combustible into the generator, lighting the material, and closing the door. The gas that formed passed through the tube to the motor. The engine man actuated the valve and allowed the gas to escape at the desired pressure. Everything, then, was the same as in the first arrangement, except that when one charge was consumed, another could at once be substituted for it, since the duplicate reservoir was all ready. But in practice, there were two generators that were put alternately in communication with the motor; while one was in operation, the second was prepared, and so on. However, I cannot too often repeat that all these apparatus were merely instruments of study, and must not be considered definitive types, but far from it.

It was with an apparatus like that shown in Fig. 2 that, on the 16th of December, we were desirous of making a decisive experiment in the presence of Mr. Edward Blanc and Count D'Herisson. A few days previous, Mr. Blanc had witnessed a successful experiment made with the apparatus shown in Fig. 1, and was therefore perfectly willing to advance us the funds necessary for the continuation of our experiments on a large scale. On the day just mentioned, Messrs. Blanc and D'Herisson were at the rendezvous on time, and immediately after their arrival on the bank of the Seine a little below the Clichy bridge, where our boat was in waiting, my friend and I, along with a lad as a steersman, went on board, while our guests were to watch our evolutions from the shore. My friend Buisson stood in front of the motor, and was to regulate the exit of the gas, while I stood in front of the generator, and the young pilot was seated near the bow of the boat and maneuvered the rudder through two ropes. Scarcely had I lighted the combustible and shut the door when my friend closed the valve, so as to obtain an immediate pressure. In fact, the pressure at once rose to 4½ atmospheres. He then opened the valve and the gas escaped with force, but the pressure dropped to zero. He repeated the maneuver, and, as the pressure again fell to zero, he closed the valve for a third time and always completely. But when he tried to open it again he could not do so, and the pressure therefore rapidly rose. On seeing the needle of my pressure gauge approach the figure 10, I quickly opened the discharge cock and the gas escaped with noise through the two lateral tubes. I was not uneasy, since I now expected to see the pressure fall, as it always had before whenever I had let out the gas through the tubes. But, instead of falling, the pressure kept on rising, and I soon saw the gauge marking 19 atmospheres. At the same time I heard a dull noise at the door. I understood the danger, for our generator had been tested only to a pressure of 20 atmospheres, and, as I saw an explosion inevitable, I bounded from the door with the intention of jumping overboard. At the same instant, an explosion occurred. All that I have described took place in a few seconds. The door, thrown like a bullet, struck me tangentially in the back, removed a skirt of my coat, and made me pivot while I was lifted to a certain height by the pressure of the gas. I was thrown into the Seine face upward, and it was in this position that I received upon the right side of the face and on the right hand a lot of inflamed combustible, while at the moment at which the explosion was about to occur I had my left side turned toward the generator. After grazing me, the door, followed by the reservoir and the 110 lb. of combustible that it contained, struck the young pilot with such force as to knock him out of sight, and forever since, up to this day, it has been impossible to find any trace of him, notwithstanding the minute searches that I have several times made at the bottom of the Seine. Buisson was crushed by the bottom of the generator which struck the motor, while the door was flying in the opposite direction. His thigh was crushed, he received internal injuries in the abdomen, and was thrown into the water, from which he was at once fished out by the crew of a towboat that was passing at the time. I, bleeding, burned, and blinded, reached the shore by swimming, scarcely able to realize what had just happened. A few minutes afterward, my unfortunate friend expired in the arms of Count D'Herisson and myself, after murmuring a few words in a scarcely intelligible voice, in which we distinguished the question "Is my friend saved?"

The cause of this terrible accident was, as I have said, the valve, the movable disk of which was, through the pressure of the gas, forced against the fixed one, so that my poor friend had not the strength to move it by revolving the hand wheel. But this circumstance would not have sufficed to cause an explosion. This day, my friend had considerably increased the quantity of priming that we were accustomed to strew over the combustible in order to make it take fire uniformly at all points; and the gas suddenly produced by the rapid combustion of this priming, which was much more inflammable than our ordinary combustible, was so abundant that its discharge through the two automatic valves and the tubes that I had opened in time could not produce a sufficient expansion. The sectors of a steel ring that held the eight steel levers of the door in place were broken at one swoop, as were also the hinges, and the door flew as would a ball shot from a cannon, projected by a pressure that must have approached (over the total surface of the door) 220,000 pounds. The force of reaction—precisely that force upon which our invention is based—then caused the cylinder to recoil in the opposite direction, and threw it with an equal force against the motor, and the shock was so violent that the bottom of the cylinder, in striking the motor, was deeply indented, while the latter broke close to the pivot and went overboard. Think of the blow that my unfortunate friend must have received as he was caught between the two cylinders. The reason that I know these details is because I succeeded in fishing from the Seine, at a depth of twenty feet, the doorless generator with indented bottom, and I have been enabled to reproduce the scene.

I cannot expatiate upon the value of this invention, nor upon its future, as the scope of this article is limited, and I fear even that I have gone too far beyond bounds. I shall simply say that the value of the invention is not at all affected by the accident, which certainly would not have happened if an imprudence had not been committed and if our means had allowed us to do things better. For, upon the whole, there was no explosion properly so called, but simply a breakage. The pressure exceeded the limit of the door's resistance, and the door gave way under a relatively feeble pressure. A fraction of an inch more in thickness, and nothing would have happened. The fact must not be lost sight of that, although this experiment failed, the invention has had a great number of successes. I hope soon to perform other experiments, and with the greatest success, as in the construction of my new apparatus I have taken an excess of precaution in order to prevent the occurrence of any accident.—*A. Ciurcu, in La Nature.*

THE "BRENNAN" TORPEDO.

A VERY decided impetus has been given to the development of defensive torpedo warfare by our government by their decision to adopt a controlled locomotive torpedo as an auxiliary weapon of harbor defense, and by their selection of a particular type of this class of weapon after a great number of careful experiments with it, extending over a period of some five years

The Russian government, some ten years since, certainly expended a large sum of money in the purchase of all the necesssary plant for the manufacture of the "Lay" controlled locomotive torpedo in Russia, and ten of these weapons were actually constructed there; but as, for reasons best known to the Russian torpedoists, no more of these weapons have been manufactured by them, Russia can hardly be said to have definitely adopted or to have shown any decided tendency toward the employment of this class of torpedo for the defense of their harbors. In America, the country that has given birth to the greater number of inventions of controlled locomotive torpedoes at present in existence, no decision has yet been come to on the question of adopting any particular type of this class of torpedo, though nearly all of these American inventions have been accorded exhaustive official trials, either at the military or naval torpedo schools. As American torpedoists generally are known to have a high opinion of the advantages accruing from the employment of the controlled locomotive torpedo for the special purposes of harbor defense, it is to be presumed that so far none of the American inventions has quite fulfilled all the conditions which they have laid down as essential to an effective torpedo of this class. Other naval powers have also carried out experiments from time to time during the last ten years with controlled locomotive torpedoes, submitted for trial by their respective inventors, but no adoption has followed, though these trials have usually terminated successfully, in so far as proving them capable of fulfilling all the advantages claimed for them. England may therefore fairly claim the distinction, for whatever it may be worth, of being the first country to definitely introduce the controlled locomotive torpedo as a component part of the material necessary for the effective defense of harbors. The controlled locomotive torpedo that our military torpedo commission have recommended the government to adopt is that one invented in 1876 by a Mr. Brennan, of Melbourne, Australia, and for the exclusive right of the manufacture of which in this country the apparently excessive sum of 110,000*l.* ($550.000) has been obtained.

The Brennan torpedo differs from all others of the same class in its mode of propulsion, which is effected by the rapid unwinding of two wires from two drums or reels carried in the interior of the torpedo, and connected respectively to the two propeller shafts, thereby causing the two propellers to revolve at a high rate of speed, and consequently forcing the torpedo through the water. The unwinding of these two wires is effected by means of a powerful winding engine placed at the starting point on shore.

Considerable interest has been evinced in this invention since its first appearance, because of the apparent paradox involved in its mode of propulsion, in that the harder this torpedo is pulled back the faster it will go ahead; but on consideration it will be seen that by hauling in the wires at a certain rate a corresponding rate of revolution is imparted to the drums, which are fixed to the propeller shafts in the torpedo, and so to the two propellers, which are thereby capable of developing a certain horse power, and if this horse power be sufficient to overcome the retarding strain on the wires, and to leave a margin of thrust, then the torpedo must be propelled through the water; and the only limit to the speed of the torpedo is apparently the strength of the wires.

The other torpedoes of this class, with three exceptions, have utilized either steam, or compressed air, or compressed gas as their motive power. Of this class may be mentioned the Lay and Patrick, with compressed carbonic acid gas; the Ericsson, with compressed air. The three exceptions are the Berdan, with the gas generated from the burning of rockets as its motive power; the Sims-Edison, with electricity generated by a dynamo at the starting point as its motive power; and the Nordenfelt, also with electricity as its motive power, but generated *within* the torpedo itself. The Brennan method of steering is also effected in a different manner from that of other torpedoes of its class, being intimately connected with its mode of propulsion, as it is effected by the varying of the speed of revolution of one or other of the drums of the winding engine, and consequently of the respective drum and propeller shaft in the torpedo, which by an ingenious arrangement causes the movement of the rudder to one side or the other. This ingenious device will be fully explained in its proper place in the general description.

The introduction of the Brennan torpedo into this country is due to the favorable report of a committee of naval officers appointed by Admiral Wilson, in command of the Australian squadron at the time when it was first brought out; on the strength of this report Mr. Brennan was ordered to bring his torpedo to England to be experimented with by the royal engineers. From that time it became a veritable pet of theirs, and now after five years of experimental work they have advised the government to adopt their child. The initial experiments at Chatham were so far successful as to the promise of greater success with an improved torpedo, that Mr. Brennan was awarded the sum of 5,000*l.* and an annual sum of 1,000*l.* for five years to complete and perfect his invention, and now that it has been adjudged perfect, he reaps the reward of all his labor by obtaining no less than 110,000*l.* from our government. Before proceeding to discuss the question of the merits and demerits of the Brennan as a particular type of controlled locomotive torpedo, or of the price paid for it, and the manner in which this sum was obtained, it will be necessary to describe its mechanism and *modus operandi.*

Fig. 1 shows a section of the torpedo; Fig. 2 is a vertical section, looking from aft, through X Y; Fig. 3 is a plan of the torpedo; Fig. 4 is a general view of the winding engine; and Fig. 5 represents the mode of using the torpedo.

The dimensions of the present Brennan torpedo are 25 ft. by 3 ft. by 2½ ft.; weight, fully equipped, 25 cwt.; speed, about 20 miles per hour; range, from 1½ miles to 2 miles.

DESCRIPTION.

I. *Mode of Propulsion.*—In Fig. 1, A and B show the two drums, or reels, on which is wound the wire by the unwinding of which the torpedo is caused to travel through the water; the fore drum, A, is attached direct to the inner solid propeller shaft, S, and the after drum, B, is fast on to the outer hollow steel propeller shaft, S^1; these two drums, by the unwinding of the wire, $w\ w^1$, are revolved in the same direction, and their respective propeller shafts also, but these only up to the point, D; at this point, D, by means of a combination of bevel gearing wheels (a precisely similar arrangement is adopted in the Whitehead—see Fig. 6), the outer hollow shaft, S^1, has its motion reversed for the purpose of revolving the two three-bladed propellers, P P^1, in opposite directions. At first sight this appears a most unnecessary complication, as, if it be only required to effect the revolution of the two propellers in opposite directions, this work could be more simply performed by taking the wires off the two drums, A and B, in opposite ways; but for the purpose of steering, it is necessary to revolve the two propeller shafts in the same direction, while to enable the torpedo to maintain as straight a course as possible

without utilizing its rudder, it is required that the two propellers should be revolved in opposite directions, as was found so absolutely necessary in the case of the uncontrolled Whitehead. The two wires, w w^1, are led from off their respective drums over the two sheaves, a a^1, respectively, through a hole made just large enough to take the wires, but without any gland in the top of the torpedo, and then through a brass eye in the fair lead, b; this fair lead, b, is swiveled on to the guard, g; the drums, A and B, are removed from the torpedo by withdrawing the inner propeller shaft, S, and taking out the fore drum, A, through a manhole in the side of the torpedo; the drum, B, is then withdrawn from its propeller shaft and removed in the same way.

II. *The Method of Steering.*—On the solid propeller shaft, S, is cut a screw thread, and immediately opposite, in the hollow shaft, S^1, a slot is cut longitudinally. A nut or collar, n, with an internal thread fits in this slot, and on the hollow shaft. This collar, n, is grooved on the outside, and in this groove work two studs on the end of a forked lever, l, Fig. 3; this forked lever, l, is carried by a bracket, m, on the side of the torpedo, and is connected at K, its other end, to a second lever, l^1, which is in turn connected to the quadrant of the rudder shaft.

From this it will be seen that any movement given in a longitudinal direction to that part of the forked lever, l, which fits in the groove of the nut, n, must transmit to the rudder a movement to one side or the other. This longitudinal movement of the forked arm of the lever, l, is effected in the following manner. So long as hole, h^1, Fig 2, placed immediately above the case, h. The Brennan may be steered from 30 deg. to 40 deg. to port or starboard, but it cannot be turned round; so that to bring it home it must be towed back by a steam launch, etc.

IV. *Maintenance of Depth.*—To steady the torpedo in a submerged run, the two horizontal steel fins, F F, Fig. 2, are provided. R R, Fig. 2, are two horizontal bow rudders, which by means of certain automatic arrangements are caused to be deflected up or down according as the torpedo reaches below or rises above the depth it is set to run at, or when it attempts to dive, or to rise. These bow rudders effect the same object in the Brennan that the stern rudders do in the celebrated Whitehead, and the only difference between the Whitehead and Brennan system of effecting the upward or downward motion as necessitated by the altered position of the torpedo from its normal direction and depth is that in the former there is an intermediate compressed-air engine, which actuates the stern horizontal rudders, but in the latter the bow horizontal rudders are directly actuated by the automatic arrangement. This arrangement consists of a balance weight or pendulum and a hydrostatic valve; one form of this valve is shown in the bow compartment, G, Fig. 1, where also is placed the balance weight. P is a piston exposed to the water on its lower face, and s s are two springs, the tension of which latter can be set to equalize the pressure of water on the lower face of the piston, P, for any particular depth at which it may be desired to run the torpedo. The movement of this piston up or for winding the wires on the drums of the Brennan torpedo are as follows:

1. The wire is first wound off the reel on which it is supplied by the makers on to a split drum, *i. e.*, a reel or drum constructed to allow of the barrel being removed after the drum has been filled with the wire.

2. This coil of wire thus formed, having a hollow core, is placed in a tank of lime water, and carefully rinsed. If it be not required for immediate use it is left in this tank for several hours, so as to maintain the wire in a good state of preservation.

3. The coil of wire is removed from the lime water tank and the wire wound on to a wooden swift—that is, a reel of the form of a cone placed on its base.

4. From this wooden swift the wire is wound on to an ordinary drum, in a state of tension, preparatory to its final winding.

5. Lastly, it is wound off this ordinary reel on to the torpedo drum. In this operation every care must be taken to insure the turns lying close together, so that the riding turns may not jam between any two of the underneath turns; and to lessen the chance of such a mishap, melted paraffin wax is poured into every opening.

On starting the winding of the wire in this final operation, the leading end is passed through a hole in one of the end plates, and fastened there; but on the winding being completed this end is cut free, with a view to prevent the wire bringing up suddenly on the whole length of it being run out; in such a case the wire is pulled out of the torpedo altogether. If for any reason

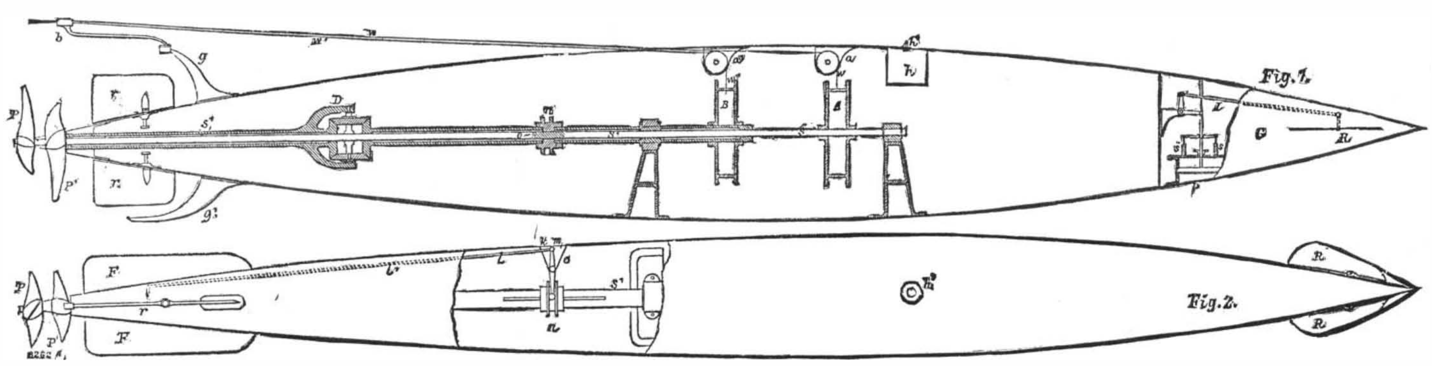


FIG. 3.

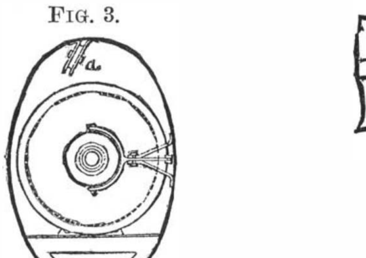


FIG. 5.

Fig. 6.

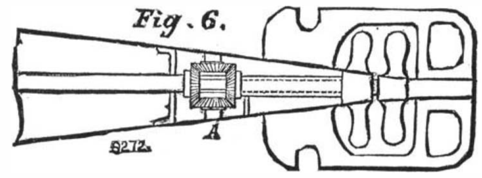
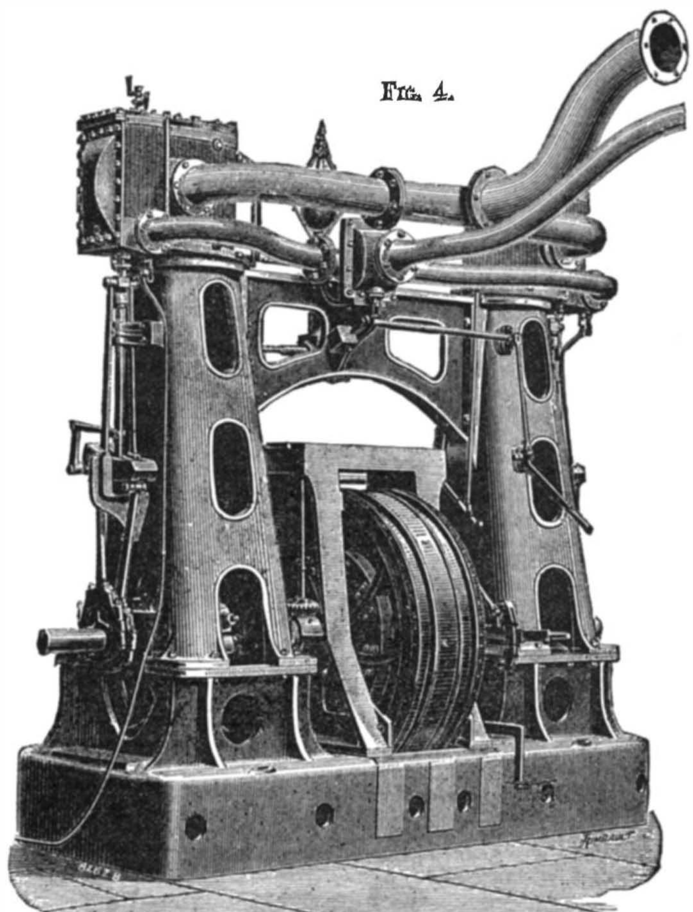
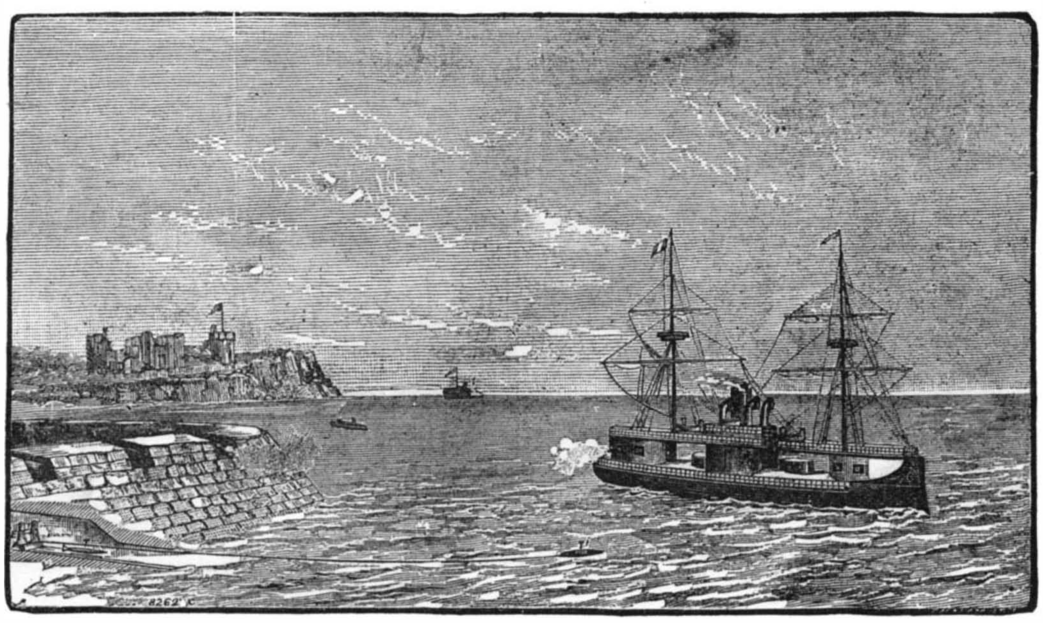


FIG. 4.





THE BRENNAN TORPEDO—ADOPTED BY THE BRITISH GOVERNMENT.

the speeds of the two propeller shafts, s s^1 (which up to the point, D, revolve in the same direction), be equal, the nut, n, with its internal thread, and the thread on the outside of the solid shaft at o, which engage, will revolve round together without any motion of the nut, n, along the shaft, s^1; but the instant a difference of speed is imparted to the two shafts, s s^1, then the nut, n, will be screwed along the shaft, s^1, either forward or aft, depending upon whether the thread is a right or left handed one, and upon which of the two shafts is increased or decreased in speed as compared with the other one. Thus port or starboard helm can at any moment be given to the torpedo during its run at the will of the officer directing it, by altering the speed of one of the shore drums.

III. *For Observing the Course*—Several means have been tried to enable the operator at any moment to know the course the torpedo may be taking when running below the surface, among which may be mentioned a float attached by a line to the back of the torpedo, and a hollow mast with signal flag, but neither of these methods has proved very satisfactory, the former proving a very erratic indicator, and the latter taking too much away from the speed of the torpedo. It has now been found necessary to trust entirely to the use of phosphorus or Holmes' light mixture, both of which when brought into contact with water emit flame and smoke in the track of the torpedo, the former being utilized for night, and the latter for day, runs. In Fig. 1, h shows the case in which this phosphorus or Holmes' composition is placed, and which is in connection with the water during a run by means of the down, corresponding to an increase or decrease of depth of the torpedo, is transferred by means of a system of levers, L, to the rudders, R R, and causing them to be deflected up or down, thus bringing the torpedo back to its normal depth. The Brennan is arranged to be run either on the surface or from 8 ft. to 10 ft. below.

Miscellaneous.—In the fore compartment, G, besides the automatic arrangements just described, is placed an ordinary self-registering instrument for recording the course of the torpedo on its run, as regards its depth below the surface at certain increments of time. Some of the records taken have registered great variations in the depth, very much more so than has ever been similarly registered by the Whitehead during the course of a run. This is only to be expected, as the longer and heavier Brennan would require more time to recover its proper depth and pass over more ground in doing so when once displaced. In actual warfare the charge of 200 lb. of gun cotton would be placed in this fore compartment. G G^1 are two steel fixed guards to prevent the vertical stern rudders and the propellers from being fouled during a run of the torpedo by hawsers, chain cables, nets, etc.

V. *The Wire.*—The steel wire principally used for the propulsion of the Brennan topedo is No. 18 W. G., breaking strain 6 cwt. to 7 cwt., weight per mile 33 lb. For any length of run three times the amount of wire is required to be wound on each drum; thus for a two-mile run, six miles of wire for each drum is needed, or twelve miles in all, equal to a weight of 392 lb., or 196 lb. of wire per drum.

VI. *Operation of Winding.*—The various operations the torpedo is stopped before the whole length of the wires has been run out, the wires must then be cut, and the four parts returned to the maker for rejointing up.

VII. *The Winding Engine* (Fig. 4).—The drums, 3 ft. in diameter, are driven by a pair of direct-acting high pressure engines, running at a great speed. Each cylinder is cast with the column under it, the latter being very strong and of such a form as to inclose the main working parts of the engine, and to prevent the wires from becoming entangled with any part of the engines in the event of either or both of them breaking. The engines are fitted with valve gear, which can be reversed or linked up so as to work expansively. The steam is admitted by means of a valve common to both engines, besides which a governor is also fitted. The drums, running loose on the shafting, are connected by a "jack-in-the-box" arrangement, by which their respective speeds can be regulated by means of a foot-brake without altering the speed of the engines. This "jack-in-the-box" is arranged as follows: Cast solid on or bolted to each drum is a miter wheel, and connecting these two miter wheels are two smaller ones, revolving on their own centers, fixed on a carrier which is keyed to the main shaft. As soon as the main engine starts, the two small miter wheels, which are in one with the shaft, are revolved with it, and carry round with them the two larger miter wheels, and consequently the drums as well. Hence it will be seen that on the brake being applied to one of the drums, the small miter wheels will be thereby caused to revolve round their own centers, the effect of which is to increase the speed of the other

drum. In proportion as the speed of the one decreases, the other increases. The columns are braced together under the cylinders by another casting, and the whole stands upon a cast iron sole plate, thus making a very rigid formation. The engine is capable of working up to 100 indicated horse power.

VIII. *The Operation of Running.*—The torpedo is placed on a launching carriage, which is constructed in such a manner that the torpedo is automatically set free, and launched or pitched clear of it into the water, on the carriage reaching the desired position on the line of rails, which are laid on an incline to the water's edge ; the hydrostatic valve is then set with the bow horizontal rudders at the proper deflection upward for the particular depth and speed it is intended to run the torpedo at, the speed being regulated by the number of revolutions given to the winding-in drums. The shore ends of the two wires are taken from the torpedo, secured to their respective winding drums, and one or two turns of the wires wound on. The carriage with the torpedo is then run down the incline, and the latter launched automatically into the water, the winding engine being at the same instant started. The torpedo then runs the required course and distance, being maintained in a straight direction for the object aimed at by the necessary movement of the stern vertical rudders to port or starboard, its course being indicated to the observer on shore by the smoke in day runs and light in night runs emitted by the contact of the water with the composition in the case, *h* (see Fig. 1).

In the sketch, Fig. 5, the winding engine is shown in a subterranean gallery in the fort, F, with the line of rails laid from it to well beyond low-water mark. E is the engine, T a torpedo on its carriage ready for launching, T¹ a torpedo running its course toward the enemy's ship attempting to pass this earthwork.

This completes the description of the Brennan torpedo and its *modus operandi*, and from this it will be evident to every one versed in torpedo matters that much of the success of this torpedo as regards three most important points, viz., "speed," "maintenance of depth," and "straightness of run," is by no means due to any special features in the original invention, but rather to the fact of its having been perfected at Chatham under the fostering care of scientific officers who are intimately acquainted with the details of the Whitehead torpedo, with all its wonderful and clever mechanism.

1. *Speed.*—The high speed of the Chatham-Brennan is due not alone to the clever mode of its propulsion, but in a great measure to the form and shape of its hull and to the perfectness of the winding engine ; the former has been proved by Mr. Froude to be the most suitable form for obtaining high speeds with the least power for totally submerged vessels (it would be adopted for the Whitehead were it not for the necessity of a cylindrical compressed air chamber) ; the latter (the engine) has been specially designed at Chatham, and constructed by Messrs. Yarrow & Co.

2. *Straightness of Run.*—Two screws revolving in opposite directions by which a wholly submerged vessel is more capable of maintaining by itself a straight course belongs to the Whitehead invention, so also is the system of gearing (shown at D, Fig. 1) by which this effect is obtained an adaptation from the Whitehead. The two screws of the Whitehead, and the gearing used for the purpose of revolving them in opposite directions, are shown in Fig. 6, from which the similarity between the Whitehead and the Brennan in this respect will be at once seen.

3. *Maintenance of Depth.*—Horizontal bow rudders worked automatically by a hydrostatic valve and balance weight, together with fixed horizontal after fins, by the combination of which a wholly submerged vessel may be maintained during its run at a fairly constant depth, is also an adaptation from the Whitehead invention.

In pointing out these facts it is by no means the intention of the writer to detract from the great ingenuity displayed by Mr. Brennan in devising and bringing to a successful issue his peculiar system of propulsion, but only to show how grievous has been the mistake of our legislators in voting the enormous sum of 110,000*l*. for the sole right of manufacture of the Brennan in this country, without first insisting on a more satisfactory and complete statement from the government than was vouchsafed by them at the time of this vote being taken, as to their reasons for asking for so large a grant of the public money for this particular invention. For, admitting the Chatham-Brennan torpedo in its present state to be perfect, and to be a valuable means of defense, it is but a combination of other inventions and ideas, the greater and principal part of which have emanated from our military scientists, and on which the country has already expended vast sums of money.—*Engineering.*

IMPROVED COLLAPSIBLE BOAT.

THE fine new steamers of the Manx line have very properly been fitted with an unusual number of life boats and life rafts. Among these are several collapsible boats, the invention of Mr. Shepherd, manager of the ship building department of the Fairfield Ship Building and Engineering Company, Limited. These boats are of the ordinary life or whale boat form, with a wide keelson attached to the wood keel piece. To this keelson are connected the frames, which are constructed, similarly to the longitudinal pieces, of galvanized steel angles, filled in with American elm. The frames are attached to the keelson at the middle line of the boat by a pivot, and are so arranged that they can be turned from the stowed position, which is nearly a fore and aft one, to the athwart ship position. When so turned and fixed, the boat acquires its proper form and strength. The thwarts are attached to the frames by a swivel pin at each end of the thwart, so that when the frames are in the stowed position the thwart hangs vertically. When the frames are turned athwart, a portable clamp of steel and wood is put on the thwarts, which are then swiveled on their pivot bolts to a horizontal position, and there held in place by a revolving button attached to the thwart. The frame, thwart, and clamp are thus all held firmly in position, and when this is effected throughout the length of the boat it assumes rigidity almost as great as that of a boat built in the ordinary way.

Along the middle line of the boat, and over the top edge of the thwart, is fixed a runner of wood supported by stanchions or pillars from the keelson. On this runner there is also a button attached to the point where it meets the thwart when turned up to the horizontal position. This button connects the runner to the thwart, and materially aids in stiffening the structure. The oars, masts, etc., are placed along the runner, which is also of use in preventing the passengers from being tossed from one side of the boat to the other when at sea.

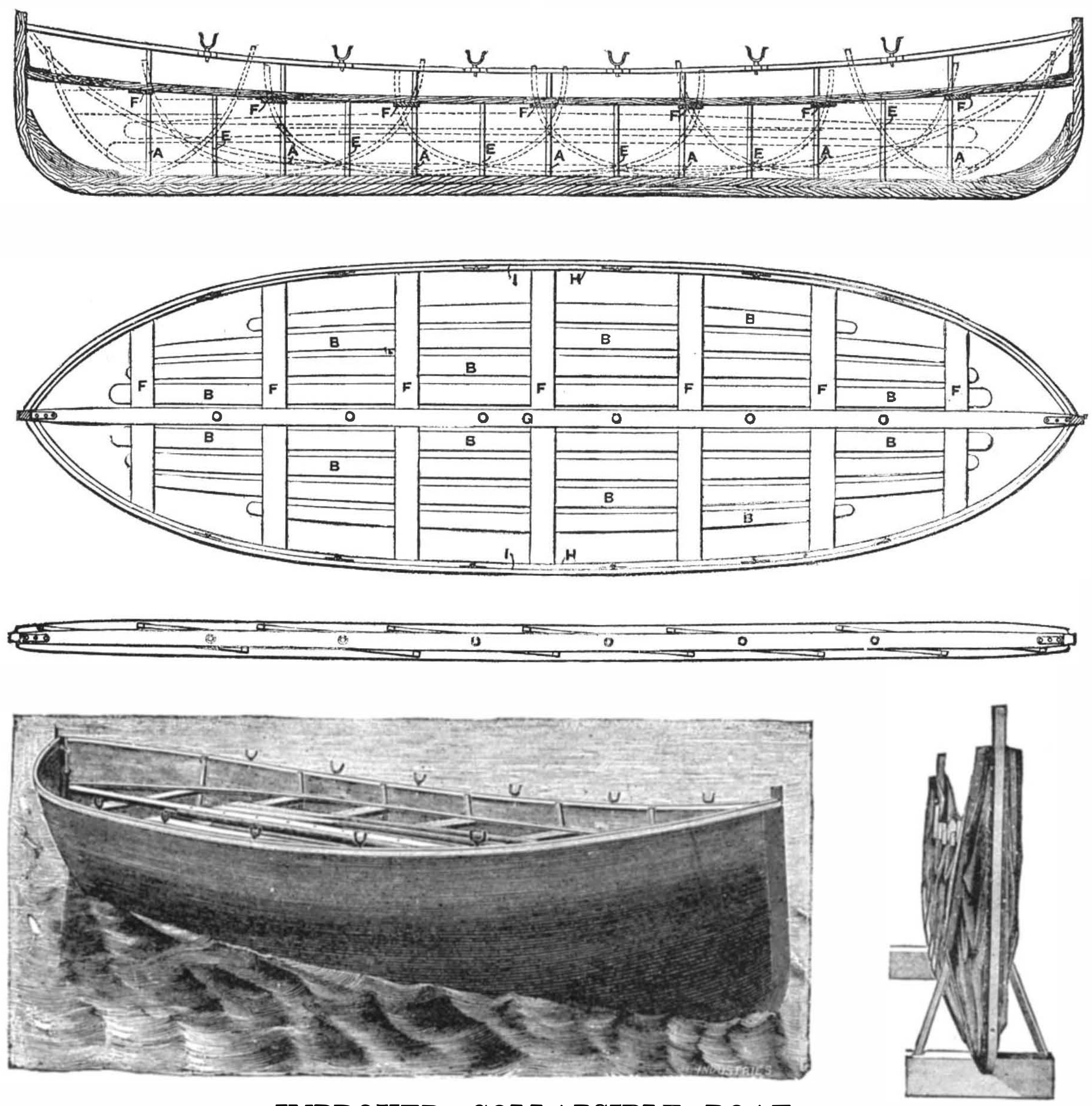
The skin of the boat is made of canvas, coated both inside and out with a special tan, which has the effect of giving it the necessary pliancy. The canvas is made of very narrow cloths, and is in two thicknesses. It is attached to the keelson stem and stern post by a fillet of wood, and at the gunwale, which is of steel and American elm, it is secured by being placed between the two materials, the steel being fastened to the wood by screws. The gunwale is attached to the stem and stern post by a plate and pin bolt or nut and screw bolt, in order that the gunwale bar may be released when the boat is to be folded up.

The gunwale bar is also connected to the frames by plates which hold both gunwale and frames in position. Pins or crutches pass through the gunwale bar, so that oars may be worked, and on the runner at the middle line of the boat a clutch is fixed to receive a mast. Foot boards are fitted as in ordinary boats. These stiffen the bottom, give footing for moving about, and afford room for stores. The bottom boards hinge and fold up between the keelson and runner, and do not when so folded take up any space beyond their width.

In the illustrations, Figs. 1, 2, and 3, the reference letters denote respectively—A, the frame, in one piece, from gunwale to gunwale ; B, the bottom boards ; C, the canvas covering ; D, the keel ; E, stanchions ; F, thwarts ; G, the center runner ; H, the side runner ; and I, the gunwales.

We also show a perspective view of the boat when opened out and in use, as well as when closed up for stowing away. The boat complete with oars, boat hook, mast, and sail weighs only 11½ cwt. When folded up, it occupies only 12 in. in width. When expanded, it has buoyancy sufficient to carry upward of sixty persons. The time occupied in expanding the boat is about three minutes, and two men suffice to perform the necessary operations. The chief point in the arrangement is the compactness of the mechanical devices, which secure convenience of storage with adequate stiffness when expanded for use.

The collapsible boat is an important addition to life-saving apparatus, mainly because of its exceeding compactness, life rafts and ordinary life boats being alike open to the objection that they encroach upon valuable space on the deck of a ship. The ample provision of such life-saving appliances insures confidence in the passengers, and is the most efficient preventive of panic and consequent loss of life.—*Industries.*



IMPROVED COLLAPSIBLE BOAT.

CARRYING WATER MAINS ACROSS A RIVER.

AT the recent meeting of the Michigan Society of Civil Engineers, Mr. W. R. Coates read a paper describing the method used by him to carry the water mains for Grand Rapids across the Grand River, which we abstract as follows :

"I first removed," he says, "the old wrought iron main, and then cleared away the slight accumulation of sand, gravel, and fragmentary rock for a space of about six feet in width on the line the new main was to occupy, and entirely across the river, thus exposing the naked limestone rock. A false work was then constructed directly over the line and entirely across the river. This false work was composed of about seventy trestles placed at intervals of twelve feet, or one trestle to each length of pipe. These trestles were connected together in such manner as to make a good working bridge from which to prosecute the work. The chief purpose of this false work was to serve as a temporary bridge on which to put the line of main together, and from which to lower it to place in the bed of the river ; but it also served an excellent purpose as a base from which to conduct the trenching operations. This bridge was eight feet in height, and ordinarily projected from two to four feet above the water, although at times the water was up to the floor plank.

"The plan adopted for making the trench for the main was, first, to clean off the sand and gravel, as already described, thus exposing the naked rock, then to drill holes at intervals of two feet on the center line of the proposed trench. These holes were carried to a depth of about thirty inches, and after being completed, were each charged with a half pound cartridge of Hercules powder. These charges were prepared in clusters of six, and exploded with electricity, a small dynamo being used for the purpose. Inserted in the upper end was an exploding cap, attached to which were two insulated copper wires, of sufficient length to reach above the water, where they were connected with wires leading to the dynamo. This dynamo was of sufficient power to explode the six charges simultaneously, and could be easily moved from one point to another, as occasion required, and it was not necessary to station it more than fifty feet from the blasts. It was not difficult to so adjust the charges as to secure the desired execution, without disturbing the false work. This very greatly facilitated operations, as without the false work for a working base, a very great amount of time would have been lost in getting to and from the work. The blasts did the best execution when the drill holes were slightly inclined from the perpendicular. In charging the blasts the cartridges were inserted in the drill holes and forced to the bottom with a long rod. The overlying water proved to be sufficient packing to secure the desired execution without sand tamping, and at the same time leave the false work free from danger from flying rock, as the rock, though sufficiently broken up to permit of easy removal, still remained in the trench, from which it was simply raked out upon the sides until after the main was laid, when it was raked back again into the trench and over the pipe, heavy, long-handled hoes being used for this purpose. The trench when finished was in most excellent form to receive the main. From each side of the river toward the center the bottom of the trench sloped gradually for 300 feet, the entire fall being only one foot, while the middle section of 200 feet was a true level. It is very rarely, indeed, that we can obtain such an even grade entirely across so wide a river.

"After the trench was complete and in readiness, the pipe was put in place upon the false work and joined together, preparatory to lowering to place in the bottom of the river. The pipe was of cast iron, in 12-foot lengths, each section weighing 1,500 pounds, and of the pattern known as socket and spigot joint pipe. The pipe was coated with Dr. Angus Smith's patent varnish, and the joints were made of hemp, gasket, and lead. I gave the joints the greatest depth of lead the socket would permit, in order to secure the highest degree of lateral stiffness. In putting the line together on the false work, it was so put together as to conform

to the shape of the trench bottom, so that when lowered to place the main would come to a bearing on the trench bottom simultaneously throughout its entire length. When the main was all in place on the false work, and the joints all made, chain slings were attached to it at intervals of twenty-four feet, or each alternate section of pipe, and to these chain slings were attached screw rods one and one-quarter inches in diameter and nine feet long. These screw rods were each provided with a double hook at the lower end, and to these the chain slings were attached. The rods, passing up through a heavy, supporting cross timber, were held in place by nuts, with lever extensions for turning them. These chains and rods were of proof metal, and capable of carrying sixteen times the load that was placed upon them. I provided this very large safety factor in order to be prepared for every possible contingency. While it was not at all probable, yet it was possible we might not be able to secure equal duty along the entire line in lowering the main. Of course if one chain and screw, from any cause, failed to carry its proper load, its neighbor would be overloaded.

"After the slings and screws were all attached, the two shore ends of the main were plugged and braced, and the main filled with water and subjected to a test pressure of 140 pounds to the square inch. The result of this test was satisfactory to all concerned. After this test the water was drawn from the pipe, as it was deemed best not to carry this extra load in lowering the main to place.

"All was now in readiness for the grand climax of the entire work. In a few short hours we were to know, from actual, practical demonstration, whether our plans were to prove a success; whether our theory and our practice would prove harmonious. The work had been observed with deep interest by the board of public works and by the citizens of Grand Rapids, and very naturally there were many doubts and fears concerning its successful accomplishment.

"The prevalent fear seemed to be that it was impracticable to handle so lengthy and heavy a line of pipe all at once, and that even if this could be done, it would be impossible to resist the force of the current when the line became fully exposed to it. From my own point of view, I had considered all serious obstacles overcome when the rock trench was completed, and that lowering the pipe to its place in the bottom of the river would be a mere play spell. And so it proved.

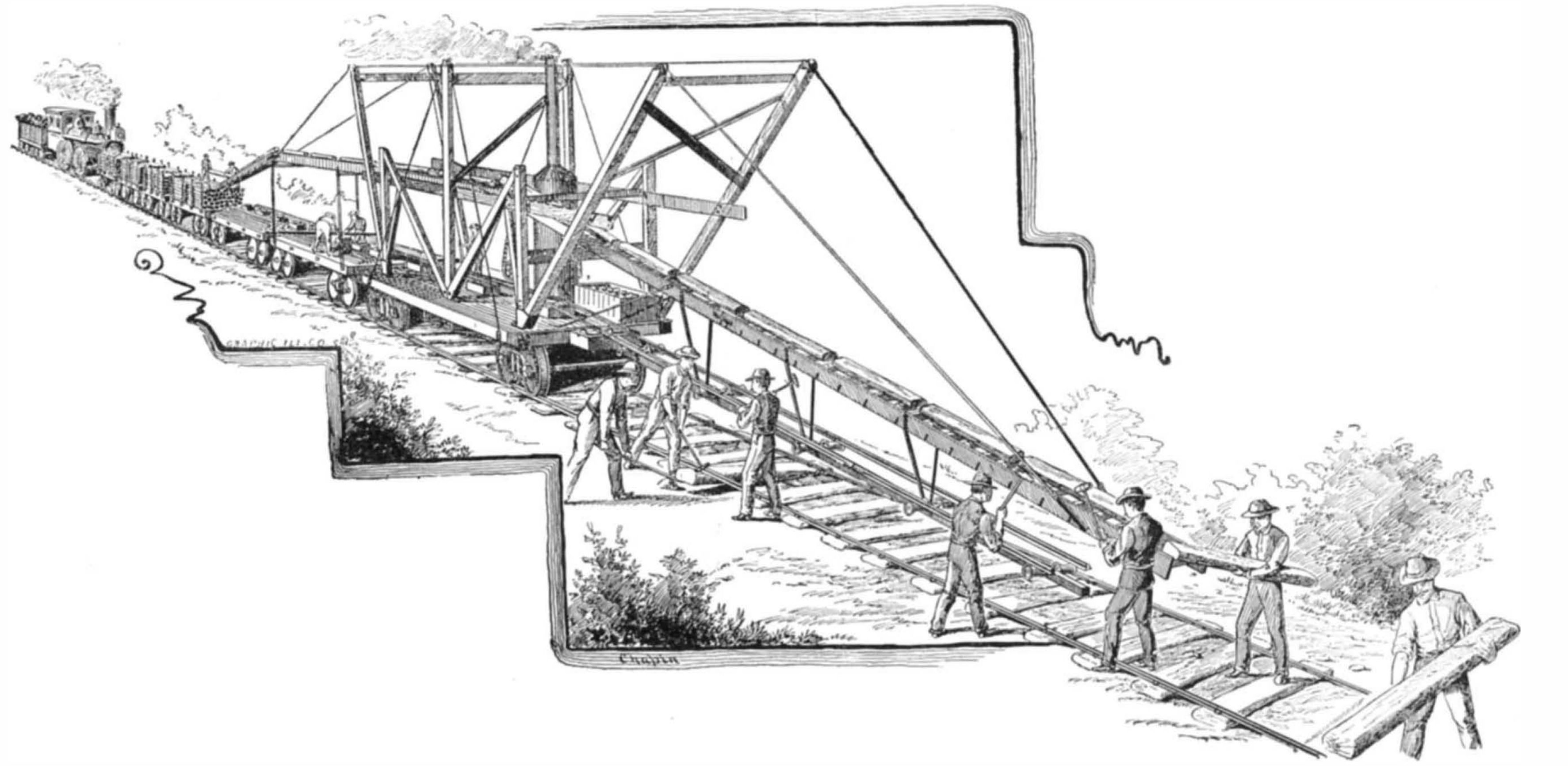
"Of course, I had carefully calculated the requirements of the situation and the means requisite for handling the main and for resisting the force of the current, and had provided amply for any and all contingencies. And this was not a difficult matter at all. There were no unknown quantities involved; everything could be mathematically demonstrated, almost as easy as two and two make four. If fifty feet of pipe could be handled safely all at once, five miles could be handled just as safely, if everything was proportioned and timed correctly. As to the great bugbear, the current of the river, five minutes' ciphering clearly demonstrated that gravity alone gave an ample factor of safety, the simple weight of our main being such that the current would not affect the line in the slightest degree. These fears and doubts proved quite a disturbing element, however, with many who were very greatly interested in the success of the work, and they were not allayed until the work was fully completed, and they were shown to be entirely groundless.

"Forty men were now stationed along the line of main, one at each screw, and a signal man with a horn was placed in the center. At intervals of ten seconds the signal man gave one blast with his horn, upon which the men at the screws each gave one full turn at the screw lever at which he was stationed. We first made a few turns to the right until the main was raised sufficiently to permit of the removal of the temporary supports from under the pipe. We then reversed, and turned steadily and uniformly, till the main reached its final resting place in the bed of the river. Two hours and a half only were occupied in accomplishing the task, and our main now rests in its rocky trench at the bottom of the river, with the entire volume of the river quietly flowing over it, instead of, as a few hours before, quietly flowing under it. While the trench in the bottom of the river was in excellent shape, yet I left all the screws attached, and under partial tension, till the trench was partially refilled and the pipe firmly bedded, after which the screws and chains were removed, the refilling of the trench completed, and the false work taken out, and now nothing remained in sight to indicate the scene of our recent busy operations. The main was again tested after it was lowered to place, and found to have sustained no injury in the process of laying. The plan here outlined for crossing rivers with water mains is superior to any with which I am familiar, and if properly executed will always insure successful and satisfactory results."

TRACK LAYING BY STEAM.

THE slow nature of the work and the enormous force required for laying track by hand or "by team" have led inventors to endeavor to perfect devices by which it could be facilitated. These devices have been chiefly notable for their half-way character. While providing mechanical means which were certainly an improvement, they have stopped short of really rapid work. On special occasions, with specially trained gangs of men, quick work has been done with them; but in practice the claims of the inventors have not been really substantiated.

It is certainly a great advantage in any case to be able to take the ties and rails directly from the end of a train which advances as fast as the rails are laid for it to run upon. In bad soil, in swampy or hilly localities, it is especially advantageous. The track-layers heretofore in use have been found to facilitate and cheapen the work, but have not made it nearly as rapid as is desirable. The chief difficulty has been to get the ties to the front as fast as needed. To overcome this difficulty Colonel Moore, who has made many years' study of this subject, has recently perfected a steam track-laying device, which has been exhibited recently in operation in Chicago. The general plan is shown very well in our illustration. The rails are handled on the forward cars. Two lengths at a time are strapped together and then quickly passed on rollers to the front and on to the ties.



MACHINE FOR LAYING RAILWAY TRACKS.

The principal improvement is in the method of handling the ties. These are carried on an overhead carrier, which is operated by an upright engine and boiler on the forward car. This carrier is made in sections of about car lengths, mounted on posts, which are held by loops or stake pockets on the sides of the car. They consist of a series of rollers with concaved surfaces, operated by detachable link belts. The ties are placed on the rollers and pass upward and over the rail cars in a continuous stream, directly to the front. The rate of delivery depends only upon the speed with which the engine is run and the quickness with which the ties can be placed. When a tie car is unloaded, a section of the carrier is quickly removed and the next one dropped, ready to go on with the work.

There is nothing complicated or hard to learn. A green gang of men can at once handle it, and should do very quick work. The inventor claims that three miles of track a day can be laid; and this seems entirely possible, although it has not yet been tested in actual work.

Our illustration conveys so clear an idea of the device that further description is hardly needed. Full particulars may be obtained by application to Mr. Abner Price, room 7, Home Insurance building, Chicago.—*Railway Review.*

HOW TO MAKE A LEYDEN JAR.

ANY person of ordinary ingenuity and some electric knowledge who has carefully examined a Leyden jar is very apt to come to the conclusion that it is a very simple thing, and easily made, and if he wants one for amateur work, for his own amusement, or to use in the class room, if he is a teacher, he is quite likely to undertake to make it, and after the expenditure of some money and a good deal of time and patience, and finding all his experiments utter failures, he either gives up disgusted, buys the article of some dealer, or patiently investigates the causes of failure, profits by his discoveries, and finally succeeds.

The latter is the true course for the scientist, who has learned from experience that failure to achieve certain expected results leads to reflection, study, investigation, and discovery; so that failure of an experiment in one sense is often the highest success in some other sense, the incidental discoveries being often of vastly greater importance than the original object of the experiment.

Such was the writer's experience, some years ago, in his attempt to make a Leyden jar, and this experience during six weeks' persistent effort, and his final success, led to very important results, so that he has never regretted the expenditure of time and effort; and it might perhaps be better to say to some amateur, "Go thou and do likewise," than to describe the proper method of procedure; but a few lines on this subject may save some one much valuable time, which can be profitably devoted to other important investigation.

The first requisite for a Leyden jar is a glass jar or bottle with a wide mouth. Such an article is apparently very easily obtained, but in 99 cases in 100 is entirely worthless for the purpose, or of very inferior value; and herein lies the chief cause of failure. Nearly all our American glass contains ingredients which so reduce its electric resistance that it fails when used for electric storage or accumulation, as required in the Leyden jar. This is especially true of fruit jars, candy jars, tincture bottles, packing bottles, battery jars, and similar glass vessels, in the manufacture of which lead, sodium, and other conductors, or partial conductors, are extensively used, which greatly reduce the electric resistance of the glass. All the nice, clear glass, known as "American flint," is of this variety, and must be avoided.

Indeed, it is better to reject all American glass, as very little of it will answer the purpose. The writer has tested a great number of samples of this glass, made at different factories and in different localities, but has never found any whose electric resistance was sufficient for a good accumulator, though some varieties of the green glass have sufficient resistance for an instrument of low grade. Imported glass, on the other hand, has a much higher resistance, and some of the best Leyden jars are made of the imported variety known as "hard flint."

English green glass, such as is used for jars and bottles in which pickles and other condiments are imported, makes the best Leyden jars, and unless some special size or shape is wanted, the shortest method is to purchase such a jar, which can be had at any large grocery, dispose of the contents, cleanse it thoroughly, and it is ready for use.

The remainder of the work is easy; and for this some light tinfoil and good flour paste are the principal requisites. Cut the foil with shears into strips about two inches wide, and five inches, more or less, in length, according to the height of the vessel. Prepare a strip of wood of sufficient length to reach the bottom of the vessel inside, while grasping the upper end as a handle; make the lower end thin and flat, and about three-fourths of an inch wide, and wrap about two inches of it with soft cotton cloth, securely fastened; and having pasted a strip of foil, apply it with this instrument to the inside of the vessel, spreading it on smoothly. Cover the inside in this way to within about three inches of the top, and the outside to the same height, and give the uncovered portion a light coat of shellac, and the jar is practically complete. A cap of wood or hard rubber with cork attached, or a common cork, can be used for a stopper, though not absolutely necessary except for convenience. A brass rod through the center of the stopper, terminating about three inches above it in a ball, and below in a light spring or chain, in contact with the tinfoil, will be found convenient for charging and discharging.

Sheet brass or tin can be used for the outside coating, soldered to a circulate brass plate at the bottom, forming a cup, and closely fitted to the jar. If brass is used, it can be nickel plated. A jar made in this way is more durable and neater in appearance than with an outer coating of tinfoil.—*Western Electrician.*

THE USE OF THE MAGNETIC NEEDLE IN EXPLORING FOR IRON ORE.*

By Mr. BENNETT H. BROUGH.

As a general rule, geological and mineralogical methods alone are used in exploring for ore deposits; only in a few exceptional cases are physical methods possible. Thus, in exploring for magnetic iron ores, the compass may afford valuable aid, and has, in fact, been employed for this purpose in Sweden and in the United States for many years. The theory of its use is based upon the fact that certain minerals deposited in the earth become magnetic by induction under the influence of the earth's magnetism, and that, consequently, the two poles are fixed in the direction of the magnetic meridian, or, more exactly, in the direction of the magnetic inclination at the opposite ends of the deposit. It is well known that there are substances, such as steel and magnetite, exhibiting polar magnetism; that is to say, they retain the magnetism once acquired, even if the inducing force ceases to act. Other substances, such as soft iron and magnetic pyrites, exhibit simple magnetism; in other words, they are magnetic only so long as the induction remains. The intensity of the magnetism exhibited by deposits of magnetite varies greatly, and is frequently so slight that only delicate instruments and practiced observers can detect it; in other cases the needle is affected at considerable distances. It must, of course, be remembered that a given magnetic force affects the needle to exactly the same degree through 100 feet of granite as through the same distance of air. If the magnetic north pole of the earth is regarded as negative, and the south pole as positive (in the northern hemisphere) the upper end of a vertical mass of ore will be negative and the lower end positive. Consequently, if a magnetic needle is brought near the upper or negative pole of the deposit, the north-seeking or positive end of the needle will be attracted. When the point of observation is very near the ore pole, the needle will dip downward. The lower or positive pole of the ore mass, being usually situated at a considerable depth, will not affect the observation. Other deposits, coursing in a more or less easterly and westerly direction, are less affected by induction; the poles being situated in the long sides of the deposit. Frequently the deposits are faulted and broken. In this case the separate portions behave like fragments of a broken bar magnet, the adjacent ends exhibiting opposite polarity. In exploring for ore, then, if, on advancing from north to south, the free needle is first attracted and then repelled, a fault in the deposit is indicated.

To explore for ore, the ordinary miner's dial or surveyor's circumferenter may be employed. If a straight line is followed with the instrument, the needle will remain directed toward the same point of the dial; or, in other words, will remain in the magnetic meridian as long as it is kept sufficiently far away from iron and magnetic ore masses; but if these are approached, the needle will gradually be deflected. The only case in which there will be no deflection is when the attracting deposit is approached along the meridian passing over its upper pole. It follows that in magnetic surveys the meridian line must first be found, and fixed in the field or on the plan. For this purpose at least two straight lines are set out in the magnetic east and west direction, from 30 to 50 yards apart. These lines will at some point cross the meridian line. If the dial is set up at one end of a line of this kind, at a considerable distance from the magnetic mass, there will, of course, be no attraction. On approaching the meridian, the needle will be gradually attracted, and at a certain distance the maximum attraction will be reached. On approaching nearer it will become smaller, until, at the ore meridian itself, it will be inappreciable. The angles of deflection observed at the various stations are noted on pegs driven into the ground, and also in the field book or on the plan. Following the same straight line to the other side of the zero point—or, what is the same thing, to the other side of the ore meridian—the same attractions are exhibited, but in reversed order; the needle turning back to the meridian. If similar observations are made along the second east and west line, it is easy to fix the ore meridian by joining the two points where there is no deflection. These points are midway between the two points of maximum deflection. This passes over the upper pole of the deposit, and if the pole is approached along the meridian line, the dip of the north-seeking end of the needle will, as a rule, be greater the nearer it comes to the pole. This method is, however, not adapted for fixing the position of the pole exactly. This may be done by determining the isogonic lines—that is to say, by joining the points where the needle has the same deflection. In order to obtain one or more parallel isogonic lines on both sides of the ore meridian, it is necessary to set out a number of lines parallel to the ore meridian, and from 10 to 30 yards apart. At the points where these lines intersect the east and west lines, the angles of deflection must be observed, and isogonic lines constructed by joining the points of equal deflection. The needle being drawn so much out of its horizontal position that its free play is hindered, it must be weighted and balanced by a piece of wax. If now from some point of intersection in the network of squares made on the field of observation a line is drawn in the direction of the deflection of the magnetic needle, it will cut the isogonic curve at a second point, and, eventually, the ore meridian. The two points where the isogonic line is cut are joined, the joining line is bisected, and at the point of bisection a perpendicular is erected; then, perpendicularly under the point where this cuts the meridian, is the upper ore pole, and at this point it will eventually be found best to sink the shaft, so as to be certain of cutting the ore mass. The ore meridian, it must be noted, need not always be a straight line. In cases where a better instrument was not available, excellent results have, in this way, been obtained with the ordinary pocket box compass, held in the hand.

For preliminary magnetic surveys no instrument is better than the Swedish compass. In this instrument the needle, besides revolving in a horizontal plane in the usual manner, can also turn in a vertical plane to an angle of about 60° with the horizon. The needle is horizontally suspended in a brass case on a long vertical brass pin by means of a long glass cap. The brass terminates above in a short steel point, on which the glass cap rotates. At the bottom of this is a brass stirrup, provided with fine holes, through which pass the horizontal pins supporting the needle. To enable the needle to dip, there is a long slot cut along the middle of it. The compass box can be suspended by means of three strings passing through three small rings fastened 120° apart on the outside of the box. It can thus be easily carried in the hand. Graduation is not usual, and indeed unnecessary. Only the cardinal points are marked, as in using it deviations from the horizontal position alone have to be noticed. This compass was invented in the last century by the celebrated Swedish miner Daniel Tilas, and is still in general use.

The dip of the needle is estimated merely by the eye, and is not actually measured. The miner's or dip compass was invented in the United States in 1886, and was adopted by the Geological Survey of New Jersey in the systematic explorations for magnetic iron ore in that State. In this instrument the magnetic needle is suspended so as to move readily in a vertical direction, the angle of inclination being measured upon the divided rim of a small compass box. The needle cannot move horizontally. When in use, the ring is held in the hand, and the compass box, by its own weight, takes a vertical position. It must, of course, be held in the plane of the magnetic meridian, which can be determined by holding the instrument horizontally. In this way it serves as an ordinary pocket compass. Messrs. W. & L. E. Gurley, of Troy, New York, make several different forms of this instrument. One with a three-inch needle has the two sides of glass, and is provided when desired with a stop for the needle. Another form has a brass back and cover and a two and a half inch needle. An improved compass by the same makers is a modification of the Swedish compass, and has a needle three or four inches long, resting upon a vertical pivot so as to move freely in a horizontal plane, and thus place itself in the magnetic meridian. While being attached to the needle cap by two delicate pivots, one on each side, it is free to dip. It is usually provided with brass covers on both sides.

With the dip compass, whether Swedish or American, perfectly trustworthy results can only be obtained when the observer is acquainted, by long experience, with the peculiarities of his instrument. Compass explorations being in many cases the sole source of income, it can easily be understood that a skillful operator will be inclined to keep his mode of procedure secret. Consequently, the uninitiated are apt to believe that the operator must be specially gifted; and frequently the supernatural properties formerly ascribed to the divining rod are transferred to the compass. This excess of faith in some is accompanied by skepticism in others. For this, unfortunately, there are good grounds, the compass being so admirably adapted for dishonest purposes. Thus, Mr. T. B. Brooks mentions an American prospector whose compass needle in the vicinity of an ore mass always showed a dip of 90° when facing west, and the true dip due to local attraction when facing east. The former position, it is said, was very successfully used in selling iron ore grounds, and the latter in buying them. Similarly, in Sweden, a powerful magnet inserted in a walking stick has been successfully employed to give a large dip to the needle when it was thought desirable to mislead the purchaser. As a rule, surveyors assume that the most ore must occur where the dip compass shows the greatest inclination, or is perpendicular. This assumption, however, is erroneous. The place where the needle is attracted most by a vertical ore bed is not directly above, but to the north of, the south pole of the deposit; for, if the magnetism of the earth is powerful enough, there must be somewhere north of the ore pole a point at which the horizontal components of the magnetism of the earth and of the ore bed are equally powerful, but acting in opposite directions. At this point the horizontal forces neutralize each other, and then the vertical forces of the magnetism of the earth and of the ore bed tend to bring the needle into a vertical position. The evidences afforded by the needle often lead to error. An unimportant pocket of ore near the surface may have as great an action on the instrument as a larger ore mass situated far below the surface. It is thus seen that in exploring for iron ore with the magnetic needle, a purely scientific method is necessary. The compass should be employed for preliminary work, in order to save time and labor; but before a shaft is sunk, recourse should be had to a more accurate method. Improved methods, available for the purpose, have been devised by Brooks, Wrede, Thalen, and Tiberg.

BROOKS' METHOD.

Mr. T. B. Brooks, of the Geological Survey of Michigan, in exploring for iron ore, determined with a pocket compass variations east or west; the bearings of a standard line being taken as in ordinary surveys. The inclinations or dips were observed on the dip compass held in the hand in the plane of the meridian. Sometimes observations were made with the compass held at right angles to this position—that is, facing north and south. The instrument was always held in the hand, and leveled by its own weight. The intensity of the magnetic force for the three positions of the compass was measured by the number of oscillations made by the needle in a unit of time, usually taken at a quarter of a minute. No attempt was made to eliminate the earth's attraction by neutralizing it with a magnet while the observation was being made, nor by computation; and the great amount of friction in the compass renders the number of oscillations only an approximation to the number that would be obtained with a delicately mounted needle. Mr. Brooks has, however, done excellent work with this method in the Marquette region and in New York and New Jersey. He also describes another method of working, which he calls magnetic triangulation. The mode of procedure is as follows: Remote from any magnetic rocks, neutralize, by means of a bar magnet, the earth's influence on the needle of a solar compass. The needle will then stand indifferently in all directions. If the compensated instrument is set up near the magnetic pole to be determined, the needle will point as nearly toward the local pole as its mode of mounting will permit. The operation being repeated at two other points near the magnetic pole, the three lines must intersect in one point, which will be directly over the pole of which the position is sought. By using a dip compass in a similar manner, data to determine the depth would be obtained. The fact that several local poles often influence the needle at each station renders this method difficult in practice; a place must be sought where but one strong pole exists.

WREDE'S METHOD.

The method proposed by the Baron F. Wrede, in 1874, consists in exploring for two points, one east and the other west of the ore mass, at which the deflections of the needle from the magnetic meridian are equal, but to the west on one side and to the east on the other. The observations are made in the ore field in the direction of the magnetic east and west line, the approximate position of which is assumed to be known. Midway between the two points there must be a third, where there is no declination. The position of the meridian passing over the ore body is thus determined. It is then necessary to determine the magnetic intensity and inclination, in order to calculate where the ore pole is situated. For this purpose it is necessary to find out the position of that point for which the horizontal component of the earth's magnetism is zero, and where the angle of inclination due to the magnetism of the ore bed alone is 90°.

THALEN'S METHOD.

Professor R. Thalen, of the University of Upsala, employs a modification of Weber's portable magnetometer, or of Lamont's theodolite. He cannot be said to have invented the instrument, since its principle has been known since Gauss' time (1830). Weber's magnetometer dates from 1836, and Lamont's theodolite from 1840. In its simplest form, the instrument consists of a compass box 3½ inches in diameter, divided into degrees or half degrees. At right angles to the diameter, passing through the zero point of the graduation, an arm extends horizontally. This serves as a sight in setting out lines in the field, and receives the bar magnet for the deviation measurements. A deflection of the needle is caused by means of this magnet, the longitudinal direction of which is parallel to the arm, and the distance of which from the needle always remains unaltered. On the other side of the compass box there is a socket, into which a rod of soft iron can be placed perpendicularly for inclination measurements. This iron rod, like the magnet, effects a deflection of the needle. The instrument rotates about a vertical axis, and is provided with a spirit level and leveling screws. In order to simplify the apparatus still further, the compass box may be fastened to a rectangular board, the edges of which can be used as sights, while the board itself receives the bar magnet, which is fixed by screws or springs into the position that is determined once for all. As support for the instrument, an ordinary surveyor's plane table may be employed. The observations with the magnetometer consist for the most part of deviation measurements, for which two different methods may be employed. In one method the instrument is placed so that the needle is directed to the zero point, the bar magnet having been removed from its place. Directly the magnet is replaced, the needle will deviate from its original position, the angle of deviation being read from the graduated circle. In the second method the instrument is turned, while the magnet is in its place, until the needle points to zero. The bar magnet is then removed, and, when the needle has come to rest, the angle is read. In this method, under similar conditions, the angle obtained will be greater than in the former method. Of the two methods, the latter, or sine method, is the more delicate; but it requires more time than the former, as the instrument has to be readjusted at every observation with the magnet and iron rod. This method has the disadvantage of not being applicable in the extreme north of the ore field, where the magnetism of the ore bed is powerful. In the former, or tangent method, the instrument remains unmoved during both measurements. The disadvantage, however, is that the so-called constants of the instrument vary with the angle of deviation. This does not matter if the results are to be arrived at geometrically, since it is then merely necessary to join the points where the same angle is obtained, quite regardless of the magnitude of the angle and of its corresponding constant. If the position of the ore is to be determined by calculations, the sine method must be employed.

Where no ore is present, the needle is acted upon by two forces, one of which is due to the fixed magnet, and the other to the horizontal component of the earth's magnetism. These two forces acting simultaneously, the needle takes up a position in the direction of their resultant. Then, if a is the angle of deviation, and H the component of the earth's magnetism, the following formulæ are obtained:

For the tangent method: $H \tan a = K_1$,
For the sine method: $H \sin a = K_2$,

in which K_1 and K_2 are constants, so long as the size and position of the magnet remain unaltered. If these constants are known, the actual value of H may be found from the magnitude of the observed angle by either of the methods. If the constants are unknown, only the relative value of H may be found. When observations are made near an iron ore field, in both formulæ H must be replaced by R, the resultant of the horizontal component of the earth's magnetism and the magnetism of the deposit. The formulæ then become

$$R \tan a = K_1, \text{ and } R \sin = K_2.$$

When the deviations are caused by the soft iron rod instead of by the magnet, somewhat similar formulæ are obtained; but the magnetism of the iron rod being due to induction, its intensity is proportional to the variations of the vertical components of the earth's magnetism. It follows that the constant, K, of each formula in this case must be replaced by a magnitude that varies with the magnetism of the rod. Observations with the iron rod indicate the inclination of the earth's magnetism, while observations with the bar magnet serve for determining the horizontal components of the same terrestrial force. Consequently, by combining the two methods, it is possible to find out the vertical components of the magnetic force.

In order to survey an ore field, it must first be divided into squares, with sides 100, 50, or 25 feet in length. Then, at every angle of these squares, the deviation must be observed with the magnet and iron rod. Similar observations must be made on ground free from iron, and so far distant from the ore field that the influence of the ore is not felt. It is also advisable

* Paper taken as read at the spring meeting (June, 1887) of the Iron and Steel Institute.—*Iron.*

to determine the magnetic declination for each point of observation. This may be done by directing the sights along one of the lines that has been set out, and reading the bearing, after the first magnet and iron rod have been removed. Observations must also be made along the magnetic meridian north of the supposed ore pole to determine where the north-seeking end of the free needle changes its direction from north to south, or whether it invariably points toward the north. When these determinations of declination, horizontal intensity, and inclination have been carefully made and the angles obtained noted on paper divided into squares, lines are drawn for each of the three series of observations, exhibiting equal declination (isogonic lines), equal intensity (isodynamic lines), and equal inclination (isoclinic lines). This is done in each case by joining the points for which equal angles were obtained. The curvature of the lines is drawn as naturally as possible, care being taken to avoid sharp bends. The curves of inclination and intensity thus constructed are closed, and have an approximately circular or elliptical shape, provided that a single isolated ore mass is being dealt with. They are grouped round two points. The one at the north is where the greatest angle of deviation was found, while that at the south is where the smallest angle was obtained. Between these two groups of curves is an open curved line representing the neutral angle. In this neutral line the intensity is the same as if no ore was present. The straight line joining the points where the greatest and smallest angles were obtained passes over the center of the ore mass, and indicates the direction of the magnetic meridian of the ore field. Directly beneath a point in this line, in a vertical ore bed, the greatest mass of ore occurs. The rule that most generally holds good in searching for iron ore is that the ore mass is to be found immediately beneath the point where the magnetic meridian cuts the neutral line. The isogonic lines consist of concentric ovals placed, as a rule, symmetrically on both sides of the meridian. From the shape and position of these curves useful indications may be obtained regarding the position of the ore pole and the shape of the deposit.

TIBERG'S METHOD.

The instruments employed by E. Tiberg consist of a new magnetic instrument for determining the inclination, a plane table, and a sighting instrument. The inclination instrument consists of a round box 3¼ inches in diameter and ½ inch deep, fixed in two square brass frames with 3½ inch sides. At its circumference it has a graduated ring, and in the middle a magnetic needle 2·36 inches in length. Its axis is at right angles to the plane of the box, and rests upon two agate supports. The needle can thus move freely when the instrument is placed horizontally or vertically.

The instrument differs from other instruments for determining inclination in that the center of gravity of the magnetic needle is a little below its horizontal axis when the instrument is in a vertical position. The needle is compensated for the vertical force of the earth's magnetism by a piece of wax fastened to its south-seeking end. The instrument is provided with a spirit level for horizontal adjustment, and with a ring, by means of which it can be suspended vertically. The sighting instrument is a brass plate about a foot in length, provided at one end with four square flanges to receive the inclination instrument for horizontal measurements. At right angles to this square there is a groove in the plate with a sliding receptacle for the bar magnet required for horizontal measurements. Four folding sights are attached to the plate in such a way that their lines of sight form a right angle. The instrument, consequently, can be used as a crosshead. Two special sights are added for leveling operations, and the instrument is provided with a circular spirit level.

The plane table employed is of the usual form. The observations for vertical measurements are made at the surface with the plane table or by hand. The inclination instrument is fastened to the plane table, leveled, and turned until the needle points to 90°. The instrument is then raised with the ring at the top, and placed at right angles to the magnetic meridian, and the angle indicated by the needle observed. The same operation has to be done by hand if the plane table is not available. When the ore appears to be deep, or when the horizontal intensity is powerful, recourse must be had to the plane table.

The formula for calculating the vertical intensity G is—

$$G = K \tan v,$$

in which v is the angle given by the needle—that is, its deviation from the horizontal—and K a constant varying in different instruments from 0·75 to 1·4 of the earth's horizontal magnetic force. Lines of equal vertical intensity may thus be constructed. In magnetic plans it is usual to employ a blue color for positive intensity, and a red color for negative intensity. The accuracy attainable with this method is from 0·2 to 0·1 per cent. of the earth's magnetic force in central Sweden. With the plane table 250 to 300 observations may be made per day, and 450 to 500 by hand. For each ore field surveyed the needle must be compensated afresh, and a preliminary magnetic survey made. The field is then divided into squares, with sides 40 feet in length. The base line is as near as possible in the middle of the field, and parallel to the direction of the strike of the deposit. In making the survey observations are made every 10 feet, and in some cases every 5 feet in the immediate vicinity of the ore, and every 20 to 40 feet or more when further distant from the ore. The general rule is to make as many observations as may be required to indicate what the appearance of the curves will be.

Heights are estimated by the eye, or by a preliminary leveling with the sighting instrument, and the more important topographical details are noted. The maximum of intensity is generally presented by the point where the ore is nearest to the surface. It may also be situated between two adjacent deposits—in which case the intensity decreases, at first slowly, or not at all, and then comparatively rapidly. The distance to the center of a vertical ore bed may be taken as at least 0·7 of half the breadth of the north polar attraction. This rule is, however, not very trustworthy. The vertical distance of the plane of observation from the upper ore pole is equal to the horizontal distance of the point where the needle deviated most from the horizontal from that where ⅛ of the greatest intensity was found. It is also equal to 1⅓ the distance of the point where the needle dipped most from that where half the maximum was found. The latter rule is the best.

Sometimes these calculations enable an opinion to be formed of the relative values of two similar ore beds. For two deposits of a similar character, situated at least 30 feet beneath the surface, it may be assumed that the deposit for which the product of the greatest intensity and the polar distance is the greater contains the larger quantity of ore for the same length of deposit. If the polar surfaces of the two beds are limited, this product must be replaced by the square of the polar distance. A good idea of a deposit may be formed from the appearance of the curves of intensity. Regular, long extended, elliptical curves, inclosing a long but narrow district of greatest intensity, always indicate a regular lenticular mass. An asymmetrical bend in the curves indicates parallel deposits. More circular curves may indicate a seggregation of ore if the intensity decreases regularly. Irregular curves indicate more or less irregular deposits. In exploring for courses of ore in the mine, a base line is marked out in the level, and observations made every ten feet at least. At each station three observations have to be made: 1. To determine the direction of the total horizontal intensity by means of the sighting instrument, the deviation of the magnetic needle from the base line being observed. 2. To determine the magnitude of its force by means of the bar magnet. 3. To determine the vertical intensity by means of the inclination instrument. Vertical measurements must also be made at the top and floor of the level, and for this purpose the instrument may be held in the hand. On neutral ground at the surface, the horizontal force of the earth's magnetism and the direction of the earth's magnetic meridian must be determined. The results of all the observations are represented on paper, along the base line, as arrows showing the horizontal forces of the magnetism of the ore at the points of observation. If all or part of the arrows are directed toward the same point, there the ore may be assumed to be. The ore would be at the level at which the observations were made, if the vertical intensity is negative. When the arrows approach in front or behind, the plane of observation is above or below the magnetic center of the ore. When the vertical intensity is positive, the ore may be above or below the plane of observation, always assuming that a more or less vertical ore mass is being dealt with.

CONCLUSION.

From the sketch of the new methods given above, it will be seen how admirably the principles of terrestrial magnetism have been applied in Sweden for the exploration of iron ores. The results are not only of scientific interest, but also of great practical importance. To illustrate this, it may be mentioned that, by applying his method, Tiberg has discovered very important deposits of ore at the mines of Langban and Sikberg. Some interesting results, too, have been obtained by Professor Thalen, who has been able, with the magnetometer, to determine the various percentages of powdered iron ore and microscopic fragments of magnetic minerals occurring in the various beds of clay at Upsala. In the same way the order of succession of beds of iron-bearing rocks can be determined. It appears, therefore, that accurate magnetic surveys would be of great value to the geologist, as well as to the miner. The value of the improved methods in the exploration and development of iron ore districts cannot be overestimated, and probably a great future is in store for them in solving questions of stratigraphical geology in districts containing magnetic rocks.

ON A NEW METHOD OF MEASURING MAGNETIC SUSCEPTIBILITY AND MAGNETIC PERMEABILITY.

By THOMAS T. P. BRUCE WARREN.

THE following method of measuring magnetic forces opens up an important branch of chemical physics, and makes magnetism itself an interesting adjunct to analytical research.

Ordinary German silver, when tested with a magnet in the ordinary way, shows no attraction whatever, but if examined in this way is decidedly attracted by a magnet. It was, in fact, from examining the contacts of electrical apparatus, to determine what metal or alloy was used, that this method of procedure was developed.

A delicate chemical balance is placed on a firm table, and in the magnetic meridian. A weight of the substance whose susceptibility is required, either in powder or fine filings, is placed evenly on the pan of the balance, and equilibrium carefully made; a powerful horse-shoe magnet is then placed directly under the pan, which is prevented from approaching within a certain distance of the magnet. Care must be taken that, in every case, it should occupy the same position. Of course it would be more convenient to employ an electro-magnet, which could be fixed, and, after adjusting the weights, the magnet could be excited by contact with a battery. When a very intense magnetic field is required, a coil of wire connected with a dynamo is placed under the scale pan.

If we are operating on a paramagnetic or positive substance, the pan will be drawn down by the action of the magnet, and weights will have to be added to restore equilibrium. The weight required to restore equilibrium is a measure of the susceptibility of the substance in hand.

If, however, we are working with a diamagnetic or negative substance, we should expect the pan to be repelled. As these so-called substances are also attracted, we are driven to the conclusion that diamagnetism as opposed to paramagnetism, in its general acceptation, has no existence; still, although a substance may have its poles, relatively to an exciting magnet, as implied by these prefixes, no case of magnetic repulsion has yet been met with.

A carefully balanced platinum crucible was found to be strongly attracted. Bismuth was decidedly attracted, but behaved with a curious sluggishness, which was very much reduced by diminishing the distance. Metallic manganese, although not affected by a magnet in the ordinary way, has a decided influence by this method of testing.

It is preferable in some cases to attach a powerful magnet to one of the ends of the beam, in place of the scale pan, as we are then independent of the magnetic influence due to the metal of the pan, and, having once balanced the magnet, we obviate the necessity of having to weigh each substance operated on.

We are indebted to Sir William Thomson for the terms magnetic "susceptibility" and magnetic "permeability," and it is in precisely the same sense as used by him that those terms are employed in this paper; thus, "susceptibility" implies that condition which ordinarily is understood of becoming magnetic, and "permeability" may be taken as meaning the power of conversely arresting the transmission of magnetic energy, or a kind of porosity.

In addition to these terms, we frequently use the expressions "retentive power" and "residual magnetism." These terms express what are practically the extremes of the same idea. Many substances are magnets when under the influence of another magnet, but as independent magnets return almost to their zero condition. The power of retaining magnetic polarity, *per se*, deserves a scientific recognition. It has now become a recognized fact that the retentive power of steel can be increased by the addition of other metals; although themselves feebly magnetic, it is generally considered that their influence is due to tempering or hardening iron.

Residual magnetism may be roughly measured by noting first the force which draws the magnet to the substance experimented on, and, after magnetizing by any of the ordinary methods, replace the same and note the alteration in the attractive force. The same method may be used for measuring the rate of acquiring, under a constant magnetic force, the maximum of induced or permanent magnetism.

In experimenting on the magnetic permeability of substances the arrangement of the magnet or magnetic field is the same as in the previous case—a plate of the metal or stratum of liquid is inserted between the magnet and some iron filings or magnet.

When the plate is removed, the magnet is attracted to within a fixed distance of the filings, the weight required to produce equilibrium is noted; the plate is then inserted, and the diminished attraction again noted. The difference in weight is due to the arrest of magnetic influence by the interposed layer.

The effect produced by differences in thickness of the interposed layer does not appear to follow the law of variation for magnetic attraction as generally accepted.

The magnetic permeability is known to be a function of susceptibility. A class of substances appear to exist which are almost magnetic insulators, but as a rule the higher the susceptibility of a substance is, the greater will be its permeability. This we might have expected.

This method of experimenting on magnetic permeability leads to the conclusion that we are not warranted in treating a vacuum as magnetic; on the contrary, we have, simply by exhaustion, altered the permeability of an interposed layer of air. When a magnetic substance is made to approach a balanced magnet, the force of attraction was as follows:

At	41·0 mm.	distance	0·026 grm.
"	20·5 "	"	0·520 "
"	14·0 "	"	1·300 "

so that at one-third the distance, in this experiment, the attraction is fifty times as great.

The magnetic force is no doubt increased, partly by the diminished distance and partly by increasing the permeability of the intervening layer of air in consequence of reducing the thickness of the stratum.

In order to obtain comparative results, the unit weight is less reliable than the unit volume. It seems to me that the unit adopted must, in the case of a substance of definite chemical nature, be a function of its molecular weight.

I am working on this matter with a view of ascertaining the magnetic equivalents of substances—that is, the weights of substances required to produce the unit force, at the unit distance, in the unit field.

A curious result of this inquiry is that in delicate chemical operations where weighing magnetic substances is concerned, we cannot disregard the intensity and horizontal force in the place where our weighings are made.—*Chemical News.*

PHOTOGRAPHY BY VITAL PHOSPHORESCENCE.

By Dr. JNO. VANSANT.

SOME months ago there was published in several scientific journals* an article in which I showed how excellent photographic positive prints, on glass or paper, could be made from an ordinary negative by means of the transformed or "stored up" radiant energy—the phosphorescent luminosity—of certain inorganic substances, especially particular sulphides of calcium and strontium.

Many organic substances also, as is well known, possess this property of storing up, so to speak, and afterward emitting, as more or less luminous rays, the radiations to which they have been exposed. Crystallized carbon, in form of the diamond, and white paper may be cited as illustrations of this class. A photographic latent image on a bromide of silver surface, capable of being developed, can easily be produced by bringing into *contact*, for an hour or so, in the dark, such a sensitive surface, and an engraving, or some ordinary printing, on white paper which has been just previously exposed for some minutes to the direct rays of the sun.

But I have now to call attention to the curious fact that the kind of light given out by certain *animal organs*, and which evidently in its causation has some close relation to the nervous system and vitality of the animal, and belongs to a different class of phenomena from the phosphorescence above mentioned, can also bring about incipient decomposition in a haloid salt of silver. Moreover, it can do this through a sheet of glass of the usual thickness used for photographic negatives, and, consequently, there is a possibility of producing by such light photographic positive prints.

The following experiment, copied from my notes, proves this:

* SCIENTIFIC AMERICAN SUPPLEMENT, Feb. 12, 1887; *Philadelphia Photographer*, April 16, 1887.

June 8, 1887.—This evening, just after dark, I took about a dozen fireflies (*Lampyris corusca*), which had been captured a few minutes before on the lawn, and inclosed them in a wide-mouthed vial of some 3 oz. capacity, having a piece of fine white bobinet (such as is used for ladies' veils) stretched over its mouth in place of a stopper. Inclosed thus, they would frequently emit the momentary flashes of greenish tinted yellow light for which they are remarkable, though usually only one insect at the same time would flash. Every few seconds one or another would emit its light for a period which I estimated to average in each case about one half of a second, and the frequency of the emissions could be increased by gently shaking the vial. When not flashing, the under surface of the three posterior segments of the firefly's abdomen, from which the light came, was scarcely at all luminous, but was simply of a bright yellow color. The flashing was plainly under the control of the insect, like its muscular movements. These fireflies are rather less than three quarters of an inch long, and the segments which become luminous have, altogether, an area of only about one eighth of an inch square. The flash is, however, quite bright, so much so that fine print can be easily seen when held close to it.

Repairing to my dark closet with the vial of fireflies, I placed it to one side, under cover, while I arranged and clamped a very sensitive gelatino-bromide of silver dry plate beneath an ordinary negative picture of a landscape on glass, as for contact printing.

The vial of insects was then inverted over the back of the negative, so that only the fine meshes of the bobinet and the glass of the negative with its gelatine film intervened between the fireflies' light and the sensitive bromide plate. I counted the flashes, occasionally shaking the vial and sliding it over the negative, till fifty flashes had occurred.

The vial was then removed, the sensitive plate separated from the negative, and an attempt made to develop the latent image, if any existed. Alkaline solution of pyrogallol was used, and in a few minutes I had the pleasure of seeing a well-marked positive image of the negative picture appear, the plate being somewhat yellow stained, as if from too long an exposure. This was fixed in the usual way with sod. hyposulp., and is now in my possession—probably the first picture ever *produced by the light emitted from a living animal organism.*

U. S. Marine Hospital, St. Louis, Mo., June 10, 1887.

—*St. Louis Photographer.*

FREEZING MIXTURES.

TABLE I.—FREEZING MIXTURES.

Composition by Weight.		Reduction of Temperature in Degrees Fahr. deg. deg. deg.
Ammonium nitrate	1 part	From + 50 to + 4 = 46
Water	1 "	
Ammonium chloride	5 parts	From + 50 to + 10 = 40
Potassium nitrate	5 "	
Water	16 "	
Ammonium chloride	5 "	From + 50 to + 4 = 46
Potassium nitrate	5 "	
Sodium sulphate	8 "	
Water	16 "	
Sodium nitrate	3 "	From + 50 to — 3 = 53
Nitric acid diluted	2 "	
Ammonium nitrate	1 "	From + 50 to — 7 = 67
Sodium carbonate	1 "	
Water	1 "	
Sodium phosphate	9 "	From + 50 to — 12 = 62
Nitric acid diluted	4 "	
Sodium sulphate	8 "	From + 50 to — 0 = 50
Hydrochloric acid	9 "	
Sodium sulphate	5 "	From + 50 to + 3 = 47
Sulphuric acid diluted	4 "	
Sodium sulphate	6 "	From + 50 to — 10 = 60
Ammonium chloride	4 "	
Potassium nitrate	2 "	
Nitric acid diluted	4 "	
Sodium sulphate	6 "	From + 50 to — 40 = 90
Ammonium nitrate	5 "	
Nitric acid diluted	4 "	
Snow or pounded ice	2 "	To — 5
Sodium chloride	1 "	
Snow or pounded ice	5 "	To — 12
Sodium chloride	2 "	
Ammonium chloride	1 "	
Snow or pounded ice	24 "	To — 18
Sodium chloride	10 "	
Ammonium chloride	5 "	
Potassium nitrate	5 "	
Snow or pounded ice	12 "	To — 25
Sodium chloride	5 "	
Ammonium nitrate	5 "	
Snow	3 "	From + 32 to — 23 = 55
Sulphuric acid diluted	2 "	
Snow	8 "	From + 32 to — 27 = 59
Hydrochloric acid	5 "	
Snow	7 "	From + 32 to — 30 = 62
Nitric acid diluted	4 "	
Snow	4 "	From + 32 to — 40 = 72
Calcium chloride	5 "	
Snow	2 "	From + 32 to — 50 = 82
Calcium chloride crystallized	3 "	
Snow	3 "	From + 32 to — 51 = 83
Potash	4 "	

TABLE II.—EVAPORATION OF LIQUIDS.

Liquid or Gas.		Water.	Anhydrous Ammonia.	Sulphuric Ether.	Methylic Ether.	Sulphur Dioxide.	Pictet's Liquid.
Specific gravity of vapor compared with air = 1·000		0·622	0·59	2·24	1 61	2·24	
Boiling point at atmospheric pressure, deg. Fahr.		212	—37·3	96	—10·5	14	—2·2
Latent heat of vaporization at atmospheric pressure, units		966	900	165	....	182	....
Absolute vapor tensions in pounds per square inch at different temperatures.	deg. Fahr.	lb.	lb.	lb.	lb.	lb.	lb.
	—40	....	....	....	....	....	....
	—20	....	19·4	....	12·0	5·7	11·6
	0	....	30·0	1·5	18·7	9·8	15·4
	+20	...	47·7	2·6	28·1	16·9	22·0
	+32	0·089	61·5	3·6	36·0	22·7	27·0
	+40	0·122	73·0	4·5	42·5	27·3	31·3
	+60	0·254	108·0	7·2	61·0	41·4	44·0
	+80	0·503	152 4	10·9	86·1	60 2	60·0
	100	0·942	210·6	16·2	118·0	84·5	79·1
	120	1·685	283·7	23·5	....	117·5	99·7
	140	2 879	....	33·5	....	....	....
	160	4·731	....	45·6	....	....	....
	180	7·511	....	62·0	....	....	....
	200	11·526	....	81·8	....	....	....
	212	14·7	....	96·0	....	....	....

CAVERNS NEAR MANITOU, COLORADO.

By H. C. HOVEY.

EVERY explorer of Colorado must have noticed the fact that, while there are many canons, there are few caverns. This fact may be explained by observing the geological peculiarities of the region. The western banks of the Missouri river are only 700 feet above the level of the sea. The plains stretching thence westward to the foot of the Rocky Mountains have a gradual upward slope, reaching finally an altitude of 6,000 feet above the sea. The underlying rocks are broad sheets of sandstone, slate, shales, and limestone. The mountain region was made by an upheaval of the lower rocks, causing them to appear at the surface, namely, granite, gneiss and trap. Along the border line between the plains and the mountains is a narrow but highly interesting region, lying nearly north and south, where the rocks of the plains appear to have been turned abruptly upward and then broken off. They must have formerly extended much farther up the mountain side than now, having since been worn away by the action of the elements. The width of this border region varies from one to twelve miles. It is a sort of geological paradise, where one may cross the edges of all the strata, from the Archæan to the Tertiary, and study to good advantage the history of their folding and erosion.

I observed that, in many places, the sedimentary rocks seemed to have been modified by the former heat of the adjacent eruptive rocks sufficiently to acquire an obscure columnar structure. Perpendicular lines of weakness were thus opened, admitting the rain water, the roots of plants and trees, and otherwise favoring the formation of canons rather than of caverns. But in certain localities the masses of homogeneous limestone were large enough to permit the excavation of grottoes of considerable size.

The most noted of the Colorado caverns are those found in the vicinity of Manitou Springs, and that add

PLOT OF THE CAVE OF THE WINDS.

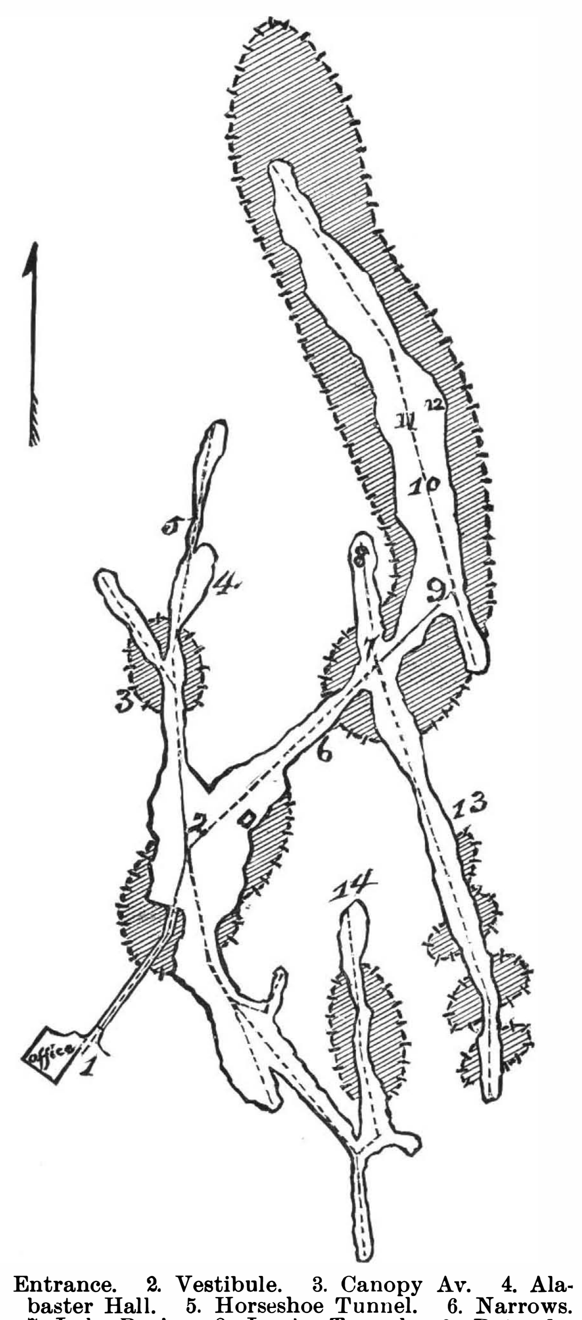
Scale, 1 in. = 120 ft. By E. O. Hovey.

The shaded portions were discovered by the Pickett Brothers, 1880.

greatly to the attractions of that remarkably picturesque region. It may not be generally realized that, within a radius of ten miles from those famous springs, are the Garden of the Gods, Glen Eyrie, Monument Park, Pike's Peak, and the Cheyenne, Queen's, Williams Canons and the Ute Pass, with its sparkling "Fontaine qui Bouille," and Rainbow Falls; added to which now the wonderful caverns, which it is my object to describe in this article.

I shall first mention "The Cave of the Winds." This name was long given to an open cleft in the limestone wall of Williams' Canon, rather more than a mile distant from the soda springs of Manitou. It is under the cap of the mountain, and some distance above the roadway. Williams' Canon is very narrow, and its almost perpendicular walls vary in height from 200 to 500 feet. Hence it is not remarkable that this rift should have remained so long unexplored. It looks from below like the mere beginning of a new canon to intersect the main one. It is about ten feet wide and seventy feet high, and spanned by a double natural bridge. A small orifice was discovered within this rift, in 1880, by two boys named Pickett. This let them into three rooms, which they explored. This part of the cave is shaded on the map. The property belonged to Messrs. Reinhart & Snider, of Manitou, who promptly took possession of the new discovery. In January, 1881, Mr. G. W. Snider, who seems to have a fondness for cave hunting, forced an entrance by drill and hammer through a seam in the limestone, that led to the discovery of perhaps thirty more rooms. The names of the various halls and chambers are not given on the map, owing to some confusion in the naming as furnished to me. They have, however, little scientific significance. The Cave of the Winds boasts an unusual growth of stalactites and stalagmites, besides satin spar, helictites, oulopholites, Epsom salts, and various other minerals such as are commonly found in limestone caverns. Extensive beds of ocher, in certain avenues, show that the subterranean stream that once flowed here, brought down from the granite hills above, decomposed feldspathic materials for these ferruginous clays, which are now hard enough to take a fine polish. Beds of rounded pebbles also occur, often coated by stalagmitic deposit. These have been by some referred to the time when the ocean washed the foot of Pike's Peak. But there has been time enough since then for the running water to cut out the whole cave; and the same agent probably rounded the fragments of granite into these pebbles. The cave in its present condition is very dry, with few standing pools.

The accompanying map, drawn by my son, Mr. E. O. Hovey, from data supplied by Mr. G. W. Snider, is as correct as anything to be had. It is on a scale of 120 feet to the inch. Accordingly, the areal dimensions of the Cave of the Winds cannot well exceed 660 feet in its longer and 300 in its shorter axis. The visitor fol-



1. Entrance. 2. Vestibule. 3. Canopy Av. 4. Alabaster Hall. 5. Horseshoe Tunnel. 6. Narrows. 7. Lake Basin. 8. Jumbo Tunnel. 9. Rotunda. 10. Music Hall. 11. Lake. 12. Organ. 13. Lovers' Lane. 14. Bridal Chamber.

PLOT OF MANITOU GRAND CAVERNS.

Scale, 1 in. = 120 ft. Surveyed by J. Robinson.

The solid line represents the contour of the floor; the curved dotted lines ◡ı◡ı◡ represent the horizontal sections of rooms wider above the floor; the straight dotted lines are the surveyor's lines.

lowing the paths and rambling around through the galleries would no doubt walk a mile or two. Only about twenty rooms are really exhibited, the remainder being difficult of access.

We shall next visit the Manitou Grand Cavern. To do so we follow the well-worn road winding up the Ute Pass. On the right are granite cliffs, and on the left the gorge through which flow the waters of Fontaine qui Bouille. We pass the lower falls, or Baths of Venus, and then shortly reach the famous Rainbow Falls, one of the most beautiful cascades in existence.

At a point about 200 yards above the falls, the carriage road leads up Cavern Canon, to Cavern Mountain —a mass of red and gray limestone, whose fossils show that, like the limestone of Williams' Canon, it belongs to the Silurian period. From the door of the cavern itself a magnificent prospect greets the eye, including high cliffs and foot hills, while in the distance the snow-capped summit of Pike's Peak is visible. This opening was discovered by Mr. G. W. Snider, in 1881, but the caves were not exhibited to the public till 1885. There were 10,000 visitors in 1886, and a still larger

number will visit it this year. Every possible effort is made to keep the contents of the cave intact from such an army of tourists, and the proprietor boasts that thus far less than 200 pounds of specimens have been removed. It is his pride to keep the cave in its native loveliness.

Three main branches of the cave lead out from the vestibule. Canopy Avenue leads northward, amid fantastic arches and alabaster pillars. This arm ends in what is called "The Horseshoe Tunnel," near which are various objects of interest, one of them being a broken column eight feet long, the problem arising as to whether it was fractured by some convulsion of nature or, like the prostrate columns in the Pillared Palace of Wyandot Cave, was felled by the Indians to obtain alabaster materials for charms and images.

Returning to the vestibule, we enter the middle or northwest arm of the cave by "the narrows," leading to the Rainbow Cascade, girt about with coral-like stalactites, some of them seeming as light as floating ribbons. The rotunda is adorned by crystal cones and sprouting stalagmites. To the right is the "Lovers' Lane," a long avenue whose chief curiosities are the stalactite and stalagmite that have been joined together after the style of an old-fashioned churn and dasher, and a group of stalagmites resembling a flock of sheep with their little shepherd. "Jumbo Tunnel" seems to be an extension of "Lovers' Lane" across the main cave, and ornamented by fine rows of stalactitic columns with three symmetrical arches. It ends in the largest stalactite in the cave. The probabilities are that the cave once extended much farther in this direction, but has been filled up by dripstone.

At the intersection of these two channels is the bed of what was once a lake. There is first the stalagmitic rim, the former margin, then follow successive ridges, like stony waves, marking the gradual recession of the waters as the dimensions of the pool diminished. Around this old lake bed are mimic statues, silvery frostwork, and alabaster cascades. The ceiling overhead is about sixty feet high, and a natural gallery encircles the room.

Beyond this is a still larger hall, whose extreme length may be 400 feet, and which has a number of attractions. It is indeed a grand cathedral, where the imagination finds the galleries, belfry, chimes, pulpit, confessional, and organ. The latter is a splendid set of musical stalactites, resonant on percussion, and singularly enough arranged in the order of the notes of the scale, so that a skillful performer can execute on them any simple melody. There is a similar phenomenon in Luray Cavern, but I do not remember to have seen it elsewhere, although musical stalactites are common enough.

The southern arm of the cave is at first a wild jumble of rocky slabs, under which is a layer of red clay. Through this clay a walk three feet wide has been dug for the convenience of visitors. Soon the scene changes. Singularly colored domes are above us. We pass what looks like a vineyard in full fruitage. The way grows labyrinthine. It seems like an underground canon, as it really is. The cavern expands into an immense room, rather barren of ornament, but impressive by reason of its size; and then it contracts to an archway, with an alabaster cascade on one side and turtle-shaped rock on the other. This romantic doorway conducts us to the Bridal Chamber—a room that every cave in America probably has; and no two of them are alike. This is really an exquisite room. The stalactitic drapery is very fine, and the walls and roof are decked by many fanciful shapes. Here are some remarkably fine helictites, or distorted stalactites, twisted by the protrusion of crystal points diverting the growth of dripstone, or perhaps in some cases by fungi, such as the mucor stalactites found in Luray Cavern.

The main points of interest are indicated on the accompanying map, prepared from an exact survey. The solid line represents the contour of the floor; the curved dotted lines represent the horizontal sections of rooms wider than the floor; the straight lines are the surveyor's lines and pathways through the avenues.

Probably I should add that, while I had the gratification of exploring this interesting border region with some thoroughness a few years ago, and passed over the localities where these caves have since been discovered and opened to the public, my materials for these articles have been obtained by correspondence with the proprietors, and not from personal exploration. In reply to my inquiries, and at my suggestion, the temperature of both the Cave of the Winds and the Manitou Grand Caverns was carefully ascertained, and is reported to vary from 52° to 55° Fahr., a fact very interesting, because that temperature agrees exactly with the temperature of Wyandot, Mammoth, and Luray caverns as ascertained by me, after repeated observations.

GEOLOGY AND GEOGRAPHY.*

IT may be doubted if any branches of science interest a larger number of persons than those that are grouped together in Section E of the American Association for the Advancement of Science, viz., geology and geography. Hence, we made arrangements this year to get abstracts of all the papers and notes of the discussions coming before this section, with the original intention of spreading them before our readers. But we find, to our surprise, that to do so with any sort of justice to the distinguished authors, we should have to devote at least an entire issue to this single subject. The mere titles of the papers read would fill two columns. We are under the necessity, therefore, of making a selection, at the risk of disappointing some of those who had kindly aided our undertaking.

The opening address of the President, Prof. G. K. Gilbert, has already been published in the SCI. AM. SUPPLEMENT. It was made the special order for Friday, and elicited warmer controversy than seemed necessary. The work of an International Geological Congress is too important to be made an occasion for personal ambition or jealousy. The effort to enlarge the American committee was in the right direction. There are eminent names that the public would like to see added. The suggestion is good that as many of the State geologists should be on the committee as can be admitted without making it unwieldy. And yet, recalling the ridicule that has been freely given to the measure, and the needless opposition it has encountered, the work it has already done is most praiseworthy, and demands suitable recognition. A vote to that effect finally prevailed, and it was also decided not to enlarge the committee at present.

The address by Prof. Drummond, on "The Heart of Africa," although geographical, and therefore coming under the limits of Section E, was delivered before the entire Association, and therefore need only be mentioned here.

Very appropriately, the section gave prominence to papers concerning the geology of New York and its environs, recent field work in southeastern New York and northern New Jersey, the limestones of Westchester County, and the eruptive rocks of the Archæan along the Hudson and elsewhere in the vicinity. After the adjournment a special party was led on an exploring tour through this interesting region, by Mr. G. F. Kunz, to enable the visitors to verify for themselves some of the statements previously made by Profs. Martin, Merrill, Britton, and Kemp. Many of the more striking facts may be found in the appendix prepared by Prof. D. S. Martin for the new edition of Appleton's Dictionary of New York City. Opportunity was given for examining the extensive cabinets of the Columbia College, the American Museum, and numerous private collections. Selected minerals were also exhibited in the section, and a geological map of the region around the city.

Another paper of considerable local interest was by Prof. Doremus, concerning the condition of the famous Egyptian obelisk in Central Park, and the successful protection of this monolith from the ravages of two winters by saturating its surface with melted paraffine wax. He exhibited large fragments of syenite that had already broken away, and stated that more than 700 pounds had thus been removed, and that the entire mass would before this have crumbled to ruin had not effective measures been taken.

Another class of papers showed the remarkable results obtained from a critical examination of the numerous deep wells lately bored in search of natural gas. Though dug in the interests of speculation, they have served a valuable scientific end, by enabling us to determine the strata underlying localities long undetermined by any surface outcrops.

One of these wells was bored at Oxford, Ohio, at a point 900 ft. above the sea level. Prof. J. F. James, who read a paper about it, said that the drill passed through various strata to a depth of 1,365 ft., or 465 ft. lower than the sea, when salt water was struck and the well abandoned. Samples had been taken of the rocks at 87 different depths, and thus a section prepared, which was exhibited, showing better than ever before the true geological formations of southwestern Ohio. This was the first well that had ever passed completely through the Trenton limestone in that region. It was reached by boring through 40 ft. of drift, 360 ft. of blue limestone and shale interstratified, clear blue shale for 380 ft. more. Then came the division between the Cincinnati group and the Trenton, 47 ft. thick, and a hard black limestone. A white limestone came next that was 445 ft. thick. At the depth of 1,280 ft. the rock became coarser, and became arenaceous still further down. The entire thickness of the Trenton was about 500 ft., with calciferous sandrock underneath it. Prof. C. S. Prosser described another well that had been drilled this year, at Morrisville, New York. Natural gas was obtained at two horizons, and a bed of rock salt was found 10 ft. thick. This well was 1,889 ft. deep, and passed through the Hamilton, Marcellus shale, Corniferous limestone, Oriskany sandstone, Lower Helderberg, Salina, Niagara, and Upper Clinton. Prof. Prosser also described the Upper Hamilton group of Chenango and Otsego counties. A deep well near Utica, New York, has particular interest, because the section thus obtained will furnish for some time to come the standard for central New York. It was described by C. D. Walcott. Its depth was 2,100 ft. It passes through the Hudson River group, the Utica shale, the Trenton, the Calciferous, the Potsdam, Pre-Potsdam, and the Archæan.

The Berea grit, from which millions of grindstones, etc., have been made, forms a persistent sandstone horizon through northern Ohio, and was described by H. B. Cushing, by the aid of five elaborately prepared sections, each running from the base of the Sharon conglomerate down to the base of the Bedford shale. By this comparison he claimed to establish the relative position of this formation.

A paper that was regarded as highly valuable by Prof. Marsh and other good judges was presented by Prof. R. T. Hill, of the U. S. Geological Survey, showing by stratigraphic and palæontological evidence that there is in Texas a deep marine group older than the base of either of those sections that include the Dakota sandstone of Meek and Hayden, and which was supposed to be the equivalent of the upper portion of the Middle Cretaceous of Europe. This entirely new group has great resemblance to the Lower Greensands and Neocomian, thus dispelling the error that the Lower Cretaceous was not represented in this country. It was shown that Texas presents the most favorable conditions for studying the Cretaceous, owing to the transitional position it occupies between the Gulf and the Nebraskan sections; both of which, except the Lower Eutaw clays, extend into the State from their typical localities, and apparently blend together. Prof. Hill also gave the characteristic fauna of the chief subdivisions of the Texas Cretaceous, and showed the stratigraphic position and range of the numerous fossils heretofore described from that region without locality or date. He said that no definite nomenclature of the American Cretaceous should be attempted until Texas had been fully studied.

The geology of another Southern State, Florida, was briefly explained by Prof. L. C. Johnson. Many of the streams in the central country sink into great cavities, and do not reappear except as large springs on the land or as fresh water springs in the sea. The people get their water supply from borings, going down to the Eocene. If the wells happen to go through this, then the whole reservoir may be lost in the underlying cavernous limestone, *e. g.*, a well at St. Augustine, which promised an abundant flow, and then suddenly went dry for the above reason. At Jacksonville, a well nearly dry was continued till it reached the nummulitic limestone, at 600 ft., when a strong flow of fine water was obtained. There is a valuable deposit of limonite in hummock land. There are phosphate beds containing numerous fossils in northeastern Florida. Great numbers of fossils are found at quarries near Jacksonville, but not one that is not found in the waters of the present day. The conclusions reached are that the peninsula is based on Eocene rocks, the outlines of which are indicated by the 100 fathom line of soundings. The backbone rises as we go south until we reach the highlands of Lake Apopka. Southward and westward of that point they form the water-bearing stratum. Though the lake region spreads out more and more, so as to occupy large portions of the country, and furnish the static pressure for artesian wells, no borings in the highlands will be successful, but only in the lowlands. Miocene strata about 80 ft. thick overlie the Eocene in most parts of the State.

Following this paper came one by W. B. Scott, concerning the Upper Eocene formations of the United States.

"The Southern Drift" was the title of Prof. J. E. Willet's paper. South of the Ohio River there is no general occurrence of drift. But, beginning near the northern drift in New Jersey, a narrow belt of drift extends through the Atlantic and Gulf States, returning to the drift near Cairo, a sweep of nearly 1,200 miles. This is supposed to have been formed by the immense floods that flowed down from the melting glacier of the north. The great beds of rounded pebbles are unique, though the sands and clays are hard to distinguish from others. The pebbles are cherty, and often show silicified fossils. The whole country traversed by the glacial floods afforded iron, which cemented the sand into sandstones and the smaller pebbles into conglomerates. These rocks are usually found near the top of the drift. In Alabama blocks of this conglomerate are used for mill-stones. Nodules of limonite occur containing extremely brilliant ochers, which may have been used as paint by the aborigines. This great belt of drift was the ancient shore line of a sea a thousand miles wide.

Prof. J. W. Spencer, of the University of Missouri, read three papers, the first on the sub-aqueous origin of the drift in central Missouri, the second on glacier erosion in Norway, and the third on the theory of glacial motion. Value was given to these papers from the fact that the author of them has just returned from an exploration of the snow fields of Europe. He found that many of the northern glaciers were rapidly advancing, a phenomenon not generally seen in the Alps. The ice reaches from rock to rock, thus forming caverns. It moulds itself about fragments so that the lower side is grooved while the stones are left behind where stranded. Bowlders were rounded as they rolled along on the ice, and not as they were torn off and shoved along by it. A loose pebble caused a tongue of ice to be pushed backward without itself being pushed along. Scratched stones were rarely seen among those that had fallen out of the glaciers, but where the ice was full of sand, the subjacent rocks were polished. Upper layers of ice were seen bending and flowing over others that were lower, when the latter were impeded by barriers. A bowlder was being crushed, not by superincumbent ice, but by the component of the total height of the sloping glacier. It is only on the ice-falls that rupture and regelation occur. Elsewhere they level, but do not dig up, the shingle. These and other observations go to show, in Prof. Spencer's opinion, that the "fluidity theory" is correct.

A valuable paper was read by W. T. McGee, of the U. S. Geological Survey, concerning what is called the "Columbia formation." This consists of a series of deltas laid down by the rivers of the middle Atlantic slope during a period of submergence varying from 100 to 500 feet, and of a series of terraced littoral deposits connecting these deltas. Its lower division is made up of bowlders, gravel, and sand; its upper of brick clay or loam. It overlies unconformably the known Cretaceous and Tertiary, and is therefore Quaternary. It represents a period of cold much earlier and longer and accompanied by greater submergence than the epoch represented by newer deposits. In other words, the Quaternary history of the United States had two epochs of cold separated by an interval of mild climate.

Maps of two new caverns near Manitou, Col., were exhibited by Dr. H. C. Hovey, of Bridgeport, Conn., who also described their history, contents, and geological relations. One of these is in Williams' Canon, and was discovered in 1880. It is called the Cave of the Winds. The other, in Ute Pass, is named the Manitou Grand Cavern. It was opened to the public in 1885. This account is published in full, with the maps, in another part of this journal.

Profs. Joseph T. and U. P. James jointly presented a paper of considerable length on the corals of Cincinnati, with a revision of species. Descriptions of 73 species of Monticuliporoidæ are given by local authorities, whose work depends on the internal and microscopic structure of these fossils. It is now proposed to rearrange them according to externals alone. This family may be subdivided properly into six principal groups: the Massive, Discoid, Laminar, Encrusting, and those assuming forms of special nature. Any student of the fossil corals will, we think, admire the simplicity of the above arrangement.

Prof. C. Hitchcock, of Dartmouth College, has been visiting the Hawaiian Islands, and brought an interesting report as to their geological features. The high islands are volcanic, while the low ones are coral islands. The ocean in the vicinity is from 16,000 to 18,000 ft. deep. According to Wallace's theory, each island is built up as a sharp cone. The lava was poured out from the bottom of the sea and then piled up to the sea level, and thus continued until the supply of lava was exhausted. This is proved by the fauna and flora. The savages used to depend on the large logs that floated thither from America; and those logs brought life and seed. These islands were probably never connected with New Zealand, as suggested by Dutton. The buttes on which he depended for proof are evidently of volcanic, not sedimentary, origin. There is a series of steps or terraces made by the flow of lava over precipices. Vast quantities of sand and ashes have been blown out from the volcanoes and deposited on the adjacent plains, till they look like deposits of alluvium.

Prof. J. S. Newberry described fifteen new species of fossil fishes discovered by Mr. Terrell in Ohio during the past year, besides twelve that have already been described elsewhere. They are all from the Cleveland shale, which is the base of the Waverly group. The

* From papers read before the American Association, New York meeting August, 1887.

paper was elaborate and illustrated by the fossils themselves as well as by figures. He also presented a paper on the Triassic rocks of New Jersey and Connecticut, showing that they represent only the uppermost portion of the European series, the equivalent of the Rhætic beds of Germany.

When we say that among the papers which we must reluctantly refrain from mentioning were contributions by Professors Winchell, Owen, Newberry, Williams, Branner, Comstock, Walcott, Fontaine, and others more or less widely known, the reader can see what a rich feast was spread for the members of Section E.

If we might offer a suggestion, it would be that there are many highly important questions of geography that ought to have their share in the discussions of the Association, and that properly belong to this section as well as the geological matters that now receive almost exclusive attention. But the record of work actually done in the recent meeting is one to be proud of; and we are gratified to have had the privilege of following it through in detail, step by step, and of meeting this noble body of students of the rocks and fossils, the minerals, metals, and soils, the caverns, mountains, and glaciers.

[Continued from Supplement, No. 607, page 9701.]

WHAT AMERICAN ZOOLOGISTS HAVE DONE FOR EVOLUTION.*

By Edward S. Morse.

The effect of mechanical strains as producing like morphological effects has been treated in a masterly way by Dr. John A. Ryder. He cites the vertebral axes of turtles and extinct armadillos, also the sacra of birds and mammals, and says: "These observed coincidences, it is believed, are neither accidental nor designed by an active cause external to these organisms or their cosmic environment. I would rather believe that the structures, so far as they have been evolved in parallel or similar ways, are the results of like forces conditioning growth and nutrition in definite modes and determinate directions. The manner of incidence of the modifying forces being in all cases determined by the voluntary actions of the organisms; the actions in turn are determined by the degree of intelligence of the animal manifesting them."

In considering the "Laws of Digital Reduction" Dr. Ryder gives a concise presentation of the various groups of animals, showing in each the line of mechanical strain in the extremities and its correlation with the increased development of those digits bearing this strain, and the consequent reduction or atrophy of those digits out of this line. These considerations led him to the following conclusions:

I. "That the mechanical force used in locomotion during the struggle for existence has determined the digits which are now performing the pedal function in such groups as have undergone digital reduction.

II. That where the distribution of mechanical strains has been alike upon all the digits of the manus or pes, or both, they have remained in a state of approximate uniformity of development.

III. It is held that these views are Lamarkian and not Darwinian, that is, that they more especially take cognizance of mechanical force as a mutating factor in evolution in accordance with the doctrine of the correlation of forces."

Dr. Ryder further says: "It seems a most convincing proof of the doctrine of descent to find man an instance of the same kind of specialization determined by the manner of the distribution of strains as is so often found among the lower groups, such as the horses, sloths, jumping mice, and even-toed ungulates."

In another memoir Dr. Ryder considers the mechanical motion in forming and modifying teeth. Considering first the simplest form of movement in the mammal's jaw, opening and closing, without fore and aft or lateral movement, he shows the successive changes going on coincident with the more complex movements of the jaw, and that the enamel foldings, ridges, crests, etc., have apparently been modified in conformity with the ways in which the force used in mastication was exerted.

Prof. A. Hyatt, in an exhaustive study of the planorbis of Steinheim, shows among other things the effect of gravitation as accounting for the form of the mollusk shell, citing examples from all the classes and even drawing examples from other sub-kingdoms to support his views.

Prof. E. D. Cope in a memoir on archæsthetism considers the hypothesis of use and effort, the office of consciousness, etc. He attempts to show that consciousness is primitive and a cause of evolution. He sustains his thesis by a series of arguments which, if not beyond my grasp, would be too extensive to present here. I can only repeat the regret I expressed in the Buffalo address, namely, that neither Professor Cope nor Professor Hyatt has yet been induced to present to the public an illustrated and simple outline of their theories. Such a demonstration, I am sure, would be acceptable not only to the public, but to many scientific students as well. While these two eminent naturalists believe fully in the derivative theory, they insist that Darwin's theory is inadequate to explain many of the phenomena and facts which they encounter in their studies. Darwin has distinctly said in his first edition of the "Origin of Species," "I am convinced that natural selection has been the main but not the exclusive means of modification;" and in his sixth edition of the same work, in quoting these words, he laments that he is still misunderstood on this point. The theory of acceleration and retardation of these authors is, if I understand it rightly, a very plain case of natural selection. It was inevitable that those individuals that matured the quickest were better prepared to defend themselves, were quicker in the field, were able to give their offspring an earlier start in the season, were in every way more fitted to survive, than those which matured later. It is assumed that this is a law when, to my mind, it seems the simplest result of natural selection. Instead of overriding it, it is only a conspicuous result and proof of it.

A parallel case may be seen in the increase in size of the brain in the vertebrates, and conspicuously in the higher vertebrates, since their first appearance in geological history. The individual brain clearly varies in size, and it does not require a great effort to perceive how, in the long run, the greater brain survives in the complex struggle for existence. Associated with the greater development, parts that were freely used for locomotion before, now are compelled to perform additional service, and through the law of use and effort, which all admit as an important factor, organs are modified in structure, the anterior portion of the body assumes a new aspect; and it was on the character of these parts and aspects that Professor Dana was led to formulate his comprehensive and ingenious principle of cephalization. It is a result and not a cause. And so I believe, though with great deference to Cope and Hyatt, that the laws of acceleration and retardation, exact parallelisms, inexact parallelisms and still more inexact parallelisms, and many other laws and theories advanced by these gentlemen, are not causes, but effects, to be explained by the doctrine of natural selection and survival of the fittest.

The connecting links and intermediate forms which the skeptical public so hungrily demand are continually being discovered. Great gaps are being closed up rapidly, but the records of this work being published in the journals of our scientific societies are as hidden from the public eye as much as if they had been published in Coptic. So rapidly have these missing links been established, that the general zoologist finds it difficult to keep up with the progress made in this direction. He can hardly realize the completion of so many branches of the genealogical tree.

Professor Cope, who has accomplished so much in this direction, says: "Those who have, during the last ten years, devoted themselves to this study have been rewarded by the discovery of the course of development of many lines of animals, so that it is now possible to show the kind of changes in structure which have resulted in the species of animals with which we are familiar as living on the surface of the earth at the present time. Not that this continent has given us the parentage of all forms of animal life, or all forms of animals with skeletons, or vertebræ, but it has given us many of them. To take the vertebrata, we have obtained the long-since extinct ancestor of the very lowest vertebrates. Then we have discovered the ancestor of the true fishes. We have the ancestor of all the reptiles, of the birds, and of the mammals. If we consider the mammals, or milk givers, separately, we have traced up a great many lines to their points of departure from very primitive things. Thus we have obtained the genealogical trees of the deer, the camels, the musk, the horse, the tapir, and the rhinoceros, of the cats and dogs, of the lemurs and monkeys, and have important evidence as to the origin of man."

In 1874 he predicted that the ancestor of all the mammals would be a five-toed, flat-footed walker with tubercular molar teeth, or in exact language a pentadactyle, plantigrade bunodont. Seven years after, he obtained evidences that such a type of mammals abounded in North America during the early Eocene Tertiary period. Professor Cope in his phylogeny of the camels shows a remarkable parallel to that of the horse, both forms appearing in the lower Eocene. Mr. Eugene N. S. Ringueberg believes he has found in a thin layer of limestone at Gasport, N. Y., a deposit in which a number of forms of brachiopods seem to present the intermediate stages between certain brachiopods common to the Clinton and the group of rocks immediately above. While the majority of species in this deposit belong to the Niagara, there are among the fossils met with three species of brachiopods which were supposed to have passed out of existence with the Clinton. He finds in this bed thirty-two forms peculiar to the Niagara, eleven common to Niagara and Clinton, three belonging to the Clinton, and two characteristic forms of the transition group. Many of these show intermediate characters.

Professor H. S. Williams in his paleontological studies of the life history of *Spirifer lævis*, in which he traces the ancestral line of this creature, says: "Whatever theoretical description we may give to species, here are in the first place an abundance of individual organisms whose remains are found in the upper Silurian rocks of Europe, Great Britain, and America, presenting a few clearly marked, distinctive characters which are found variously developed in the individual forms, but so grading in the various varieties as to cause careful naturalists to associate them as varieties of a single species."

Dr. C. A. White, in his comparisons of the fresh-water mussels and associated mollusks of the Mesozoic and Cenozoic periods with living species, expresses his belief that the present Unios of North America, particularly those forms allied to *Unio clavus*, have come down in an unbroken line from the Jurassic and possibly from earlier times. He shows that thus far all the fossil Unios have been obtained from lacustrine deposits, none of these beds being distinctly fluviatile. He furthermore calls attention to the fact that "these lacustrine formations are of very great extent in western North America, and without doubt the lakes in which they were deposited were caused by encircling bands of rising land during the elevation of the continent. These great land-locked waters were at first brackish, but finally became and for a long time remained fresh, continuing so until their final desiccation." From this commingling of salt and fresh water he justly assumes that many modifications arose in the forms of Unios subjected to these influences, and hence has resulted a variety of forms which have gone on continually widening to the present day.

Prof. A. G. Wetherby, in a paper on the geographical distribution of certain fresh water mollusca and the possible cause of their variation, shows the paucity of forms of Unionidæ on the Pacific and Atlantic coasts as compared to the richness and profusion of those forms in the central portion of the continents. He remarks also on the absence of the family Strepotomidæ east of the Alleghanies. He assumes that the first fresh-water forms were lacustrine. He points out the well-known geological fact of large inland inclosures and their subsequent drainage, and shows the vicissitudes which must have been encountered by species in the variety of physical conditions implied by these changes. In this connection I may be permitted to call attention to the fact that at a meeting of this association, at Hartford, in 1874, I made a communication on the origin of the North American Unionidæ in which I urged some of the points made by Dr. White and Professor Wetherby.*

Dr. Thomas H. Streets, in studying the immature plumage of the North American shrikes, was much struck with the close resemblance between the plumage of the young of *Sula cyanops* and the adult plumage of another species. Recalling a generalization made by Darwin that "when the young differs in color from the adult, and the colors of the former are not, as far as we can see, of any special service, they may generally be attributed, like various embryological structures, to the retention by the young of the characters of an early progenitor." He then shows the gradation between the several species of shrikes from this standpoint, and traces their descent from a common ancestor.

Prof. S. A. Forbes, in a study of the "Blind Cave Fish and their Allies," is led to review the conclusions reached by Prof. F. W. Putnam in his interesting papers on the subject. Professor Putnam brought forth a number of arguments which seemed to him to militate against the views urged by evolutionists that their peculiar characters were adaptive and the result of their cave life. He was led to the conclusion that the absence of light had not brought about the atrophy of the eyes, the development of special sense organs, and the bleaching of the skin. In referring to another cave fish, Chologaster, with eyes fully developed, it was urged that the argument in regard to eyeless fishes could have no weight. In response to this it was answered that possibly Chologaster had not been subjected to subterranean influences long enough to be affected, and this objection was anticipated by urging that we have no right to assume that Chologaster is a more recent inhabitant of the caves, until proved.

The discovery of another species of Chologaster, taken from a spring at the base of a limestone cliff in Illinois, has given Professor Forbes an opportunity to make careful comparisons with the cave Chologaster. He says with regard to it: "The most important and interesting peculiarity of this species indicates a more advanced stage of adaptation to a subterranean life than that of its congeners." Referring to Professor Putnam's arguments, Professor Forbes says that "the discovery of a species of Chologaster which frequents external waters of an immediate subterranean origin supplies all needed proof that the genus either has a shorter subterranean history than Amblyopsis, or, at any rate, has remained less closely confined to subterranean situations; and that in either case the occurrence of eyes, partial absence of sensory papillæ, and persistence in color are thus accounted for consistently with the doctrine of 'descent with modification.'" In this connection it may be of interest to read the curious fact recorded by Mr. S. H. Trowbridge of the discovery in the Missouri river of a shovel-nosed sturgeon which had the skin growing over the eyes, completely inclosing them. Dr. S. H. Scudder, in a memoir read before the National Academy, brings forward evidence to show that ordinal features among insects were not differentiated in Paleozoic times, but that "all Paleozoic insects belonged to a single order which, enlarging its scope as outlined by Goldenberg, we may call Paleodictyoptera; in other words, the Paleozoic insect was a generalized Hexapod, or more particularly a generalized Heterometabolon." In a memoir on the earliest winged insects of America, embracing a re-examination of "The Devonian Insects of New Brunswick," published by the author, Dr. Scudder replies to some sharp criticisms and objections made by Dr. Hagen, and pertinently says that "there is no evidence—but the contrary—that Dr. Hagen in his investigations uses the 'theory of descent' as a working hypothesis, without which no one studying any group of animals in the period of its rise and most rapid evolution can expect to do otherwise than stumble and wander astray. To refuse it is to merit failure."

Prof. J. S. Kingsley, in his study of Limulus, regards it as an Arachnid, but states that its ancestor takes us back to a time when the distinctions between the Crustacea and Arachnida were far less marked than now.

Dr. A. S. Packard, in a paper on the "Genealogy of the Insects," shows by means of a "genealogical tree" the descent of the class from the Thysanura, with some hypothetical creature not unlike Scolopendrella as the probable stem form of the Hexapods. It is through the resemblance the larvæ of the different orders of insects bear to various members of the Thysanura that this scheme is justified. It may not be out of place to say here that the use of the "genealogical tree," in suggesting the probable line of descent of various allied groups, has been severely condemned by some as leading to no practical good in classification. It seems to me, however, the only clear scheme for the proper working out of the ascertained or hypothetical relationships of animals; it is thought-exciting, its very attitude provokes studious inquiry and suggestive inferences. It may be called the modern tree of knowledge.

The modern genealogical tree as used by the biological student (and as well by the ethnologist, philologist, and others) is a graphic diagram of the relationships between groups as understood by the projector, and, as such, is a most commendable and useful method with which to illustrate his meaning. With additional knowledge one can see, at a glance, the points that need strengthening, and he can pare, prune, or even graft new fruits on the old stock, or if it is rotten at the trunk, cut it down altogether. These trees have always been in vogue with the older naturalists, only, in the old style of arboriculture, the trunk was always kept stiffly vertical while the branches were bent down and trained horizontally, being flimsily attached to the main stem by printers' devices of long and short brack-

* Address of the retiring President of the American Association for the Advancement of Science, New York, August 11, 1887.

* The following is a brief abstract which was published in the Hartford *Courant*, August, 1874. "Mr. Morse, in explaining the origin of the North American Unionidæ, did not pretend to point out the absolute line of descent in these forms, but wished to call attention to some curious features in the possible derivation of the fresh-water families of mollusks from cognate genera living in salt water. It is observed, first, that the few families of fresh-water mollusks are intimately related to those forms which live in the sea between high and low water mark, and those which can withstand the influence of brackish water. He cited certain families of fresh water mollusks which are so closely related to tidal forms as hardly to be distinguished from them. . . . In explaining the immense number of species of fresh-water mussels in America compared to the very few forms in Europe, we might look to an explanation of this feature in the past geological history of the two continents.

"In Europe there have been no great inland seas, while in America its past history shows the inclosing of large tracts of water in which freshening from brackish water went on, and while many forms succumbed to these changed conditions, only those forms survived which resemble certain littoral species. And with the curious modifications that must have taken place in these changed conditions, one gets a possible explanation of the great variety of mollusks in our Western rivers."

ets In this attitude it reminded one of the dwarfed and deformed trees of the Chinese, and very properly typified the dwarfed and deformed way of looking at classification.

Never was the provisional use of a genealogical tree more completely justified than in a memoir by Dr. Alexander Agassiz on the "Connection between Cretaceous and Echinid Faunæ." He certainly speaks in no uncertain terms when, in considering the Spatangoids of the chalk, he says, "They lead us directly through the Paleostominæ and the Collyritidæ to the Ananchytidæ which have persisted to the present day;" and other relationships of the same nature are repeatedly urged as would not only justify the use of the genealogical diagram against which he so strongly inveighed in his admirable address before this association at the Boston meeting, but had he adopted this method a much clearer view of the very points he wished to emphasize would have been afforded his readers.

It was the strictures of Agassiz above referred to that led Prof. W. K. Brooks to write a paper on the subject of "Speculative Zoology," in which he most earnestly and ably defends the use of genealogical diagrams and justly says: "If phylogenetic speculations retard science, speculations upon homology must do the same thing, and the only way to avoid danger will be to stick to facts, and, stripping our science of all that renders it worthy of thinking men, to become mere observing machines."

Since 1876 Professor Marsh and Professor Cope have in various journals and government publications presented the results of their discoveries of the past vertebrate life of North America. The general government has published the two great monographs of Professor Marsh on the Dinocerata, an extinct order of gigantic mammals, and the Odontornithes, an order of extinct toothed birds, as well as Professor Cope's great volume on the Tertiary Vertebrata, besides other memoirs by the same authors. Space will forbid more than a passing allusion to the varied and remarkable additions to our knowledge of extinct vertebrate life made by these naturalists.

Had a moiety of the work accomplished by these investigators been known to Geoffroy St. Hiliare, the theory of descent would have been established long before Darwin, though to Darwin and Wallace belong the full credit of defining the true cause. Leidy, Marsh, and Cope have not only brought to light a great number of curious beasts, many of them of gigantic and unique proportions, but forms revealing in their structure the solution of many morphological puzzles and throwing light on the derivation of many obscure parts.

The discovery in the western Tertiaries of multitudes of huge and monstrous mammals, and, earlier still, of gigantic and equally monstrous reptiles, naturally led at once to an inquiry as to the cause of their extinction. "Nothing can be more astonishing," says Prof. Joseph Le Conte, "than the abundance, variety and prodigious size of reptiles in America up to the very close of the Cretaceous, and the complete absence of all the grander and more characteristic forms in the lowest Tertiary; unless, indeed, it be the correlative fact of the complete absence of mammals in the Cretaceous and their appearance in great numbers and variety in the lowest Tertiary. . . . . The wave of reptilian evolution had just risen to its crest, and perhaps was ready to break, when it was met and overwhelmed by the rising wave of mammalian evolution." In this paper of Le Conte's, which is entitled "On Critical Periods in the History of the Earth, and their Relation to Evolution; and on the Quaternary as such a Period," may be found an excellent rejoinder of Prof. Clarence King's lecture before the Sheffield Scientific School on the subject of catastrophism and evolution.

Among the most interesting discoveries connected with these creatures is the determination by Professor Marsh that these early mammals, birds, and reptiles had brains of diminutive proportions. He says in regard to the order Dinocerata, a group of gigantic mammals whose remains have been found in the Tertiary deposits of the Rocky Mountain region, that they are the most remarkable of the many remarkable forms brought to light. The brain of these creatures was remarkable for its diminutive proportion. So small, indeed, was the brain of *Dinoceræ mirabile*, that it could "apparently have been drawn through the neural canal of all the presacral vertebræ." In alluding to the successive disappearance of the large brutes, the cause is not difficult to find. "The small brain, highly specialized characters, and huge bulk, rendered them incapable of adapting themselves to new conditions, and a change of surroundings brought extinction. The existing Proboscidians must soon disappear for similar reasons. Smaller mammals, with larger brains and more plastic structure, readily adapt themselves to their environment, and survive, or even send off new and vigorous lines. The Dinocerata, with their very diminutive brain, fixed characters and massive frames, flourished as long as the conditions were especially favorable, but, with the first geological change, they perished, and left no descendants." Professor Marsh says that the brain of Dinoceras was, in fact, the most reptilian brain in any known mammal.

Professor Cope, in describing the brain of Coryphodon from the deposits of New Mexico, says "the large size of the middle brain and olfactory lobes gives the brain as much the appearance of that of a lizard as of a mammal." This is one of the lowest mammalian brains known. There are others from the lower Eocene with equally low brains, as Arctocyon of Gervais and Uintatherium of Marsh. Cope believes that the type of brain of these early creatures is so distinct as to necessitate the erection of a third sub-class of equal rank with the groups Gyrencephala and Lycencephala, which he would define as the Protencephala. He shows their approximation to reptiles.

Cope refers to Gratiolet as showing that a great development of the olfactory is a character of an inferior type; in fact, the more we ascend into paleontological antiquity, the more we find that the olfactory lobes display a greater development in comparison with the cerebral hemispheres. Dr. B. G. Wilder has shown that in the lamprey the only part which can be regarded as a cerebral hemisphere lies lateral of the olfactory lobe. In Dipnoi he finds that the cerebral outgrowth is ventral. In another paper he says: "In either of these directions, in which what may be regarded as the special organ of the mind is projected among these low or generalized forms, there would seem to be mechanical obstacles to any considerable expansion; but dorsally there is opportunity for comparatively unlimited extension, and it is in this direction that the hemispheres begin to develop in the Amphibia and attain such enormous growth in birds and mammals." How far the small brain and presumably stolid intellects brought about the extinction of the huge Tertiary mammals may be better understood by the suggestions offered by Prof. A. E. Verrill in a lecture at Yale College entitled "Facts Illustrative of the Darwinian Theory." He shows what an important factor parental instinct is in the evolution of species. He regards the lack of parental care "as one of the probable causes, though usually overlooked, of the extinction of many of the large and powerful reptiles of the Mesozoic age and of the large mammals of the Tertiary." He says: "The very small size of the brain and its low organization in these early animals are now well known, and we are justified in believing that their intelligence or sagacity was correspondingly low. They were doubtless stupid and sluggish in their habits, but probably had great powers of active and passive resistance against correspondingly stupid carnivorous species. But unless the helpless young were protected by their parents, they would quickly have been destroyed; and such species might, in this way, have been rapidly exterminated whenever they came in contact with new forms of carnivorous animals, having the instinct to destroy the new-born young of mammals and the eggs and young of oviparous reptiles. Thus it would have come about that the more intelligent forms, by the development of the parental instinct for the active protection of their young against their enemies, would have survived longest, and therefore would have transmitted this instinct, with other correlated cerebral developments, to their descendants."

Prof. John Fiske, in his Cosmic Philosophy, arrived at a similar conclusion in regard to early man. He showed that when variations in intelligence became more important than variations in physical structure, then they were seized upon to the relative exclusion of the latter.

The derivative theory has not only clearly revealed the fact that animals have been derived from pre-existing forms, but it shows even more clearly that organs have been evolved as well. It is difficult in a general review of this nature to clearly separate the two classes of facts.

Professor Cope has traced the genesis of the quadritubercular tooth in the mammals of the present day. He finds that the type of the superior molar tooth of the mammals of the Puerco epoch was triangular or tritubercular, that is, with two external and one internal tubercle. Of forty-one species of mammals of this epoch, all but four of them had this type of tooth. He finds that this tooth exists to-day only in the insectivorous and carnivorous marsupials. In brief, he shows a gradual change taking place from the early primitive type of tooth in the gradual development of another tubercle. The same author, in defining the characters of an ancient order of mammals, the Amblypoda, says they are the most generalized order of hoofed mammals, being intermediate in the structure of their limbs and feet between the Proboscidia, the Perissodactyla, and Artiodactyla, which fact, together with the small size of the brain, places them in antecedent relation to the latter, in a systematic sense connecting them with the lower mammals with small and smooth brains still in existence; and in a phylogenetic sense, since they precede the other orders in time, they stand in the relation of ancestors.

Professor Cope, in a paper read before this association on the "Classification of the Ungulata," gives special attention to the arrangement and character of the carpal and tarsal bones. He shows that "the weaker structure of the carpus and tarsus appears first in time; that the stronger structure appeared first in the posterior limbs, and that the interlocking structure has greatly multiplied, while the linear has dwindled and mostly disappeared. Here is a direct connection between mechanical excellence and survival."

In the light of Mr. Caldwell's unquestionable determination of the oviparous character of that curious mammal, the duckbill mole, associated with its known reptilian bearings as deduced from its skeleton and other features, the deductions of Prof. Cope regarding the "Relations between the Theromorphous Reptiles and the Monotreme Mammalia" are of great interest.

In the Theromorpha are two divisions, one of which, the Pelycosauria, is limited to the Permian, and of one of this group he makes the following comparisons: 1. "The relations and number of the bones of the posterior foot are those of the mammalia much more than those of the reptilia. 2. The relations of the astragalus and calcaneum to each other are as in the Monotreme *Platypus anatinus*. 3. The articulation of the fibula with both calcaneum and astragalus is as in the Monotreme order of mammals."

In brief, he shows the affinity of this reptile to be with the monotremes, and that the affinities are very important in the light of Mr. Caldwell's researches, and the further fact that the development of the egg is meroblastic confirms, so to speak, the reptilian affinities of the Monotremes.

Here then are a series of observations by different observers from different standpoints, all telling the same story. Osteologists have long ago pointed out the reptilian affinities of the monotremes from the character of the skeleton. The anatomists in like manner have insisted upon certain reptilian characters as well as avian characters from its internal structure. A trained zoologist now studies it on the ground and finds it laying true eggs—a fact that had been insisted upon several times in the present century. More significant still, the study of these eggs shows that they go through a reptilian mode of development. And now the paleontologist brings to light the remains of a reptile from the Permian rocks, and again establishes the same relations.

In this connection the examination by Dr. Henry C. Chapman of a fœtal kangaroo and its membranes is of interest. The fœtus he examined was fourteen days old. He states that it had no true placenta, and says: "If the parts in question have been truthfully described and correctly interpreted as partly bridging over the gap between the placental and non-placental vertebrates, they supply exactly what the theory of evolution demands, and furnish, therefore, one more proof of the truth of that doctrine."

(*To be continued.*)

GERMANIUM.

THIS new element, which is exciting considerable attention among chemists, was discovered by Clemens Winkler, of Freiburg, in the early part of the year 1886. The constant error of about six per cent. in the result of his analysis of a comparatively simple mineral led him to suspect the presence of one or more new elements.

Such a suspicion was well founded, and, as the result of an exceedingly careful and painstaking investigation, he succeeded in isolating a new substance, which conducts itself in every way like an element; and, what is of still more general interest, a careful study of this new simple body and the compounds which it forms with other elements shows, it can be said almost conclusively, that it agrees in properties with the *eka-silicium* of Mendelejeff.

The silver ore from which germanium is obtained, and which is now known in mineralogy as argyrodite, is found in the neighborhood of Freiburg, and the analysis of the mineral has shown it to have the composition represented by the formula $3Ag_2S.GeS_2$. According to this, it may be regarded as a sulpho salt for which mineralogy furnishes no analogues.

In order to extract germanium, the mineral in which it occurs is fused with an equal weight of a mixture of equal parts of flowers of sulphur and soda ash. The fused mass is then boiled with caustic soda, and the solution thus obtained is neutralized with dilute sulphuric acid. This is then filtered. To the filtrate dilute sulphuric acid is again added, when the sulphide of germanium is thrown down. This is filtered off and washed with dilute acid containing hydrogen sulphide, and finally, by treating the washed precipitate with strong nitric acid and evaporating to dryness, germanium oxide is obtained, which may be reduced either by heating to redness in a current of hydrogen or by heating a mixture of the oxide and starch in a covered crucible. In this way germanium is obtained in the form of a dark gray powder, which melts under borax glass at 900° C.

The element is found to be extraordinarily brittle, and to have a strong tendency to crystallize in the regular system. It has a fine metallic luster. In color it is grayish white, considerably whiter than zirconium. At 20·4° C. it has been found to have a specific gravity of 5·469.

Germanium is not acted on by hydrochloric acid, but is easily dissolved in aqua regia. Nitric acid converts it into a white oxide with liberation of the oxides of nitrogen. Treated with concentrated sulphuric acid, it yields a white, crystalline sulphate, sulphur dioxide being liberated in a constant stream during the action. It is not acted on by potassium hydroxide in the cold.

The atomic weight of germanium has been determined by two entirely different methods: 1st, volumetrically, by determining the amount of chlorine in the tetra-chloride, $GeCl_4$, according to the method of Volhard; and, 2d, from calculations based on the wave lengths of certain lines in the spark spectrum. By the former method the atomic weight has been found to be 72·32; by the latter 72·28. The very close agreement of this number 72·28, as representing the atomic weight of the new element, with that of the unknown element between gallium and arsenic on the one hand and titanium and zirconium on the other, in the table of Mendelejeff, has naturally led to a very careful comparison of the properties of germanium with those of eka-silicium, whose properties were predicted by Mendelejeff as early as 1871. The results of the comparison will be best seen by presenting them in tabular form:

Eka-Silicium, Es.	*Germanium, Ge.*
Atomic weight, about 72	Atomic weight, 72·32 and 72·28.
Density, 5·5.	Density, 5·469.
Atomic volume, 13 nearly.	Atomic volume, 13·25.
Will form an oxide, GeO_2.	Forms an oxide, GeO_2.
Sp. gr., 4·7.	Sp. gr., 4·703.
Easily obtained by reduction with carbon or sodium.	Easily obtained by reduction with carbon or hydrogen.
A dirty gray metal, fusible with difficulty, forming the oxide when heated in air.	A gray white metal, fusing at 900° C., and forming the oxide when heated in air.
Will form a chloride of the composition $EsCl_4$, which will boil near 100° C., probably lower. EsO_2 will form a hydrate soluble in acids. This solution will probably decompose readily, yielding an insoluble hydrate.	Forms a chloride having the composition $GeCl_4$, which boils at 86° C.
The sulphide will be insoluble in water, but probably soluble in ammonium sulphide.	The sulphide is moderately soluble in water, more readily soluble in ammonium sulphide and the alkalies.
The metal will decompose steam very slowly, be scarcely acted on by acids, but easily by alkalies.	Not acted on by hydrochloric acid. Soluble in aqua regia. Nitric acid converts it into the oxide. Sulphuric acid gives the sulphate with liberation of sulphur dioxide. Not acted on by a concentrated solution of potassium hydroxide, but violently by the molten hydroxide.
It will form volatile organo-metallic compounds, and will occur in minerals containing titanium and niobium.	Occurs in a silver ore of composition $3Ag_2S,GeS$.
According to L. Meyer, this element will be:	
Easily fusible,	Fuses at 900° C.,
Volatile,	Easily volatile,
Electro-negative,	Probably electro-negative,
Brittle.	Very brittle.

A comparison like this shows that we have here to deal with a case similar to that which presented itself when gallium and scandium were discovered, and

shown to be identical with eka-aluminum and eka-boron respectively, and a careful consideration of the results already obtained seems to show that, in all probability, the eka-silicium of Mendelejeff and the germanium discovered by Winkler are the same elements.—*Journal fur prak. Chemie*, 34, 177; *Amer. Chem. Jour.*, *J. H. K.*

A NEW LOCAL ANÆSTHETIC.

By J. Herbert Claiborne, Jr., M.D., Instructor in Ophthalmology in the New York Polyclinic; Attending Surgeon to the Northwestern Dispensary, Eye, Ear, and Throat Department, New York, etc.

During the past fall Mr. M. Goodman, V.S., in traveling through West Feliciana Parish, La., had occasion to apply a poultice to the fetlock of one of his horses. Having none of the customary means at hand with which to make it, he raked together a number of leaves from the ground, and having saturated them with hot water, applied the mass as a poultice to the inflamed part. After the swelling had arrived at the proper condition, he made a free incision into the part without the horse giving any evidence of pain. It occurred to him that the leaves might have anæsthetic properties; and a few weeks after, having occasion to open an inflamed bursa on the elbow of another horse, he made a similar poultice, applied it as before, and again made the incision without any pain to the animal.

Dr. Allen M. Seward, of Bergen Point, N. J., having obtained, through Mr. Goodman, some of the leaves, made an analysis of them. He found a number of constituents, among them an alkaloid, and having excluded all others as the anæsthetizing element, concluded that this virtue lay in the alkaloid. He made a two per cent. solution of the alkaloid, and settled the point by obtaining local anæsthesia in a cat's eye with several drops. Mr. Goodman informs me that the tree is known in the locality mentioned as the tear blanket tree.

It grows to the height of thirty-five to forty feet, with a diameter to the bole of about eighteen inches and a spread of foliage of about thirty to thirty-five feet. The leaves resemble those of an acacia. The bark is smooth. From the ground up the tree is furnished with clumps of forked spines or thorns, the parent spine springing at right angles from the bough or trunk. Though Mr. Goodman is a native of the region, he has never seen the tree blossom. As fruit it bears pods eight or ten inches in length, flat and slightly curved, containing seeds and a viscid juice.

The spines are very tough and highly polished, and the wood is extremely tough. It grows in clumps and singly, and is abundant in Louisiana.

From the likeness of the tree to the Acacia stenocarpo, Dr. Seward dubbed the new alkaloid stenocarpin. It would have been better, however, to withhold the naming of the alkaloid until the botanical name of the tree had been known.

Through the kindness of Dr. Seward I was put into possession of two drachms of a two per cent. solution of the alkaloid.

[The details of various successful applications of the drug to eyes, ears, and skin are then given.]

In further proof of the anæsthetic effect on the skin, I submit the following:

An Irishman of fifty years presented himself at the Northwestern Dispensary with *otitis media catarrh. acuta.* I observed a sebaceous tumor on his forehead, between the hair and the left eye. I suggested to him to have it removed, telling him that I thought it could be taken away without any pain. He consented. A thin piece of cotton was saturated with the solution and tucked over the tumor and its vicinity; in twenty minutes the skin could be pricked without any pain. In ten minutes more I made a long horizontal incision across the tumor, dissected the skin from around the sac down to the bone, and removed it *in toto.* The man sat perfectly still and said nothing during the whole operation, save at one point, where I made a deep sweep into the connective tissue; he merely observed it scratched a little. Several drops of the solution were immediately instilled in the neighborhood, and in a few seconds I continued to the end without another word from him. When asked if it hurt, he said he had often been hurt worse by the scratch of a pin. Passing of suture caused no pain, and the wound, dressed antiseptically, healed by first intention. The patient seemed very much surprised when I showed him the tumor, and expressed himself as dumfounded.

I have made no experiments on the physiological effect of the drug when introduced into the general system. It should be borne in mind that only a limited quantity of a two per cent. solution was used in the above experiments.

From analogy it would be reasonable to expect that the anæsthetic effect would be increased by stronger solutions. In its effect upon the eye it seems to stand midway between atropine and cocaine. Its anæsthetic effect lasts about as long as that of cocaine; its mydriatic effect is greater than that of atropine, while its paralyzing effect upon the muscle of accommodation is perhaps as great as that of atropine, reaching its maximum effect in about six or seven hours, and disappearing rapidly thereafter. It would seem to be indicated wherever cocaine is, so far as its anæsthetic properties are concerned, and where atropine is, so far as its mydriatic properties are concerned. In fact, for irides rendered sluggish by inflammation, it seems to be superior to atropine, though the duration of its effects, as we have seen, is by no means as great.

In Dr. Allis' case I was not able to detect any difference in tension, even when the pupil was dilated *ad maximum.*

After examining a number of eyes at the same time, I may confidently say that in seven instances I have observed a *diminution* in tension when the pupil was dilated *ad maximum*, though I have not been able to detect it in all cases. If this property can be settled beyond a doubt, it will truly possess a phenomenal characteristic, of peculiar interest with reference to glaucoma. The contraction of the opposite pupil, though it has not been observed in all cases, was marked in several, particularly in Dr. Allis'.

From the foregoing observations its therapeutic value in eye diseases cannot be inconsiderable.

There is no reason to assume that it will not cause anæsthesia of all mucous surfaces, as it has been shown to do in the eye and nose. In view of the results obtained by myself, I feel safe in predicting for it a wide field of usefulness in all departments of surgery where local anæsthesia is desired, and it only remains for further experiment to develop all its possibilities.

It may fairly be reckoned as a rival of cocaine.

Dr. Seward informs me that the winter leaves yield seven and a half grains of the alkaloid to every ten pounds, while the summer ones yield only **five** grains to every ten pounds. The supply of the alkaloid is very small at present and the price very high. An ounce of a two per cent. solution costs $6, which would give sixty cents as the cost per grain. These figures remind one strongly of the market value of cocaine soon after its introduction.—*Medical Record.*

MILTON JOSIAH ROBERTS, M.D.

By J. J. Sullivan, M.D., New York.

The professor of orthopedic surgery and mechanical therapeutics at the New York Post-Graduate Medical School and Hospital, Dr. Milton Josiah Roberts, is distinguished not more for his innovations in the operative methods of bone surgery, which mark a distinct advance in that department of science, than for his numerous and valuable original contributions to the subject of mechanical therapeutics as applied to the relief of suffering, the cure of disease, and the prevention of unsightly bodily deformities. Though he started late in life, handicapped with ill health, empty hands, and restrictions in opportunities, he has, during his short professional career, won a reputation for practical scientific attainments which might well satisfy the ambition of a much older man.

The Hon. Andrew D. White, late president of the Cornell University, and former United States Minister to Berlin, in introducing by letter the subject of this sketch to a distinguished university president, wrote September 22, 1885: "The bearer of this, Dr. M. J. Roberts, is a *genius.* He proved this at Cornell, by his fertility in resources, as regards scientific investigations, and he has proved it in a more striking degree since."

Prof. Roberts was born in Norwalk, Huron County,

MILTON JOSIAH ROBERTS, M.D.

Ohio, August 30, 1851. His parents and grandparents were farmers, and all of them were characterized by their industry, frugal habits, integrity of character, and great physical strength. During the early years of his life, his parents lived in a log cabin built on a small clearing in the midst of a dense forest. When about seven years old, he was stricken down with a severe and almost fatal illness, the result of imprudent exposure in midwinter. For more than seven years thereafter he was so delicate in health that he was necessarily deprived of all educational advantages.

When ten years of age he was taken by his father to Ann Arbor, Michigan, to be treated by a cousin who was then practicing medicine in that place. While under treatment, he served as an office boy to his cousin. Here he first came in contact with patients. He soon became practically familiar with much of the routine work of the office, and evinced a special interest in the progress which patients made toward recovery.

After a number of months, he returned to his home on the farm, where he attended school winters, and worked on the farm summers.

In 1869, he took up the independent study of shorthand, copying from a borrowed book the principles of Ben. Pitman's system in a single night. From this time he became a persistent note taker of things observed and work done, which practice he has ever since continued. His fondness for the study of natural history objects was always marked. Whenever an opportunity offered, he would go into the fields and woods. He was fond of fishing and of hunting wild birds and animals. He made an extensive collection of butterflies and other insects, and began to practice the art of taxidermy, getting the first hints from an Iowa agricultural report. He made his first scalpel by grinding down a large and thick old-fashioned razor. With this he afterward skinned and dissected many hundreds of birds and other animals. He collected and mounted nearly all the species of birds, mammals, reptiles and fishes indigenous to the section of country in which he lived. He compiled a manuscript work on the art of taxidermy, trapping, shooting and hunting wild birds and animals, with an appendix on the training and care of game dogs.

In January, 1870, his health again failed him, and he went to Florida. During his six months' stay in Florida, he made an interesting collection of natural history objects, including birds, their nests and eggs, mammals, fishes, reptiles, insects, and some flowers and plants. After returning home, he worked on his father's farm, and became expert in the use of all agricultural machinery. In repairing machines of this class, which he was frequently called upon to do, he developed considerable mechanical skill.

While at college he contributed materially to his support by working at rough carpentry on President White's house, then being built, putting in five hours' work five days in the week, and ten hours on Saturday.

In 1871, he entered Cornell. In 1872, he was obliged to leave college, on account of the ill health of his father. In December of the same year he was again obliged to leave college, and to take his father, who suffered from asthma, to Florida. On this trip he visited the uninhabited parts of Florida, and collected natural history specimens.

In September, 1873, he re-entered college, though in poor health and suffering continually from malarial symptoms.

Now he began to assume for the first time the responsibility of shaping his course of study to his own liking. From civil engineering his mind was ever reverting to his first love. He desired to become a naturalist, but saw no opening in that field of knowledge that would insure him a comfortable subsistence. He, therefore, decided to study medicine. He spent much time in the anatomical laboratory, working under the direct supervision of Prof. Burt G. Wilder, the distinguished comparative anatomist. For a time he contributed to his support by making tiles, house painting, paper hanging, and other work which he could get to do. His first publication was an article entitled, "Among the Florida Keys," which appeared in the January number of the *Cornell Review* for 1874.

At college he took a special course in veterinary science, under Prof. James Law, and frequently assisted that distinguished veterinarian in major surgical operations upon domesticated animals.

He was appointed taxidermist to the university, a vacancy having occurred in that department. Here he found congenial exercise for his natural tastes, and the knowledge he had already acquired in this direction now came in good stead. The increased wages which he was able to earn by doing skilled work afforded him more time for study. He mounted a large number of birds and mammals, ranging in size from a humming bird to a dromedary. At his instigation, and with the co-operation of President White, Professor Law, and Professor Wilder, rooms were fitted up by the university authorities for the preparation of skeletons. He acquired wonderful skill in the use of the scalpel, and could make what is technically called a "skin" of a small bird in the short space of a minute and a half. At one time he was employed on the *Weekly Ithacan*, to write locals and special articles. With the idea of further increasing his ability to contribute, under varying circumstances, to his support, he took up the art of wood engraving, and resumed the systematic study of short hand, in addition to his regular studies and university work.

In October, 1875, he read an original paper before the Natural History Society of Cornell University, entitled "The Anatomy of a Feather: having two million two hundred and fifty-one thousand four hundred and one parts."

Prior to leaving the university, he donated to that institution his entire collection of mounted and unmounted birds, mammals, reptiles, etc., made by him, together with an herbarium of plants and sea algæ, which had been made by his mother while she was in California. The plan for the construction of the museum cases which contain the Green Smith collection of birds at Cornell, as well as his own zoological collection, was suggested by him.

On September 13, 1876, Mr. Roberts entered the medical department of the University of the City of New York, with Prof. Burt G. Wilder, of Cornell University, and Prof. William H. Thomson, of New York, as preceptors.

He made phonographic reports of lectures for the university professors upon which he afterward was obliged to pass examination. These he wrote out on the type writer. This work served the double purpose of increasing his medical knowledge and materially

contributing to his support. While prosecuting his medical studies, he made and published an original contribution to phonography. He also compiled a manuscript work on medical short hand. In company with Prof. William H. Thomson, his preceptor, he walked the wards of Bellevue and Roosevelt Hospitals, making notes of important cases, and conducting qualitative and quantitative chemical examinations for Prof. Thomson, when necessary. While a student in 1877, he took three courses of physical diagnosis, and attended numerous cases of confinement.

He selected for the subject of his graduation thesis, "Museums as Educational Adjuncts to Medical Colleges," which was one of two essays that received honorable mention out of a class of 154 graduates.

February 14, 1878, he passed his medical examination, and on the same day accepted the invitation of Dr. C. E. Billington to become his assistant at the out-door department of the Demilt Dispensary.

In 1879, he assisted Dr. John S. Warren, of the deparement of diseases of women at the Demilt Dispensary, and took charge of the work in this department during Dr. Warren's vacation.

In January, 1880, he was appointed a subordinate assistant at the surgical clinic of Professor J. Williston Wright. At this clinic most of the orthopedic cases were turned over to his charge. He was thus afforded abundant opportunity of studying the class of cases in which he was so much interested.

In the fall of 1881, he was appointed professor of surgical pathology in the American Veterinary College, and delivered the inaugural address at that institution October 3, selecting as his subject, "The Art of Scientific Discovery in Medicine."

His first medical contribution was a paper read before the New York County Medical Society, Jan. 22, 1881, entitled, Elastic tension and articular motion as therapeutic agents in mechanical treatment of chronic inflammations of joints, with a description of new apparatus for the knee and wrist joints. This was followed, during the same year by the following contributions: Elastic tension therapeutically utilized in adhesive and medicated plasters; Elastic tension apparatus for dislocation of the humerus; Elastic tension apparatus for anchylosis of the knee joint; Remarks on carotid compression as a means of euthanasia; Elastic tension in Pott's disease; Non-uniformity in the principles of treating Pott's disease, as taught by Professor Sayre; Elastic tension and articular motion in Pott's disease; and The mechanical treatment of caries of the lumbar vertebræ.

On June 15, 1881, he was appointed instructor in orthopedic surgery and mechanical therapeutics in the new Post-Graduate Medical School, and was subsequently made assistant secretary of the faculty.

In October, 1882, he was appointed visiting orthopedic surgeon to the city hospitals on Randall's Island, furnishing recommendatory testimonials from Professor Wm. A. Hammond, Professor D. B. St. John Roosa, and other distinguished members of the medical profession.

From this time onward his contributions to medical literature have been many and important. His medical inventions have been numerous and valuable.

Of these inventions the following may be mentioned: elastic tension knee splint, with tibial rotating mechanism; elastic tension knee splint without tibial rotating mechanism; radio-carpal elastic tension splint; elastic tension adhesive and medicated plasters; elastic tension apparatus for dislocation of the humerus; elastic tension apparatus for anchylosis of the knee-joint, with and without posterior extension mechanism; elastic tension device for attachment to plaster of Paris or other spinal jackets, to overcome lateral tilt; elastic tension spinal traction bars, with brackets for sectionized spinal jackets; improved form of inconspicuous elastic tension head rest; elastic tension apparatus for cervical caries; improved elastic spinal traction bars; short bilateral elastic tension hip splint; the electro osteotome; a protecting retractor; two new forms of silver wire suture instruments; elastic tension knock knee splint; long bilateral elastic tension, or self-acting, non-traumatic hip splint; long bilateral self-acting hip splint, with elastic rotating, abducting and adducting mechanism; inside elastic tension, or non-traumatic hip splint; outside elastic tension, or non-traumatic hip splint; a new inconspicuous head rest, whereby all the movements of the head are regulated by elastic force; improved "jury mast;" short bilateral non-traumatic or elastic tension ankle splint; long bilateral non-traumatic ankle splint; elastic tension apparatus for elbow joint disease; elastic tension apparatus for anchylosis of the elbow joint, with supinating and pronating mechanism; a new spinal corset woven out of wire to fit the contour of the body; combination apparatus for the support of the head and the supination of the hands; swinging crane for elastic suspension; modified tricycle, with foot pads, for exercising lower extremities; apparatus for inversion of the feet; combination apparatus for the support of the head, trunk, and upper and lower extremities; the articular goniometer; the adjustable protractor; the epipedometer; improved electro osteotome; measuring staff, with goniometric attachment; the electric celioscope for the illumination of the interior of bones and cavities in general; elastic tension apparatus for shoulder joint disease; tape measure attachment, enabling the observer to make uniform traction upon the tape; circumferential outline tape for obtaining circumferential outline of cross section of any part of the body; instrument for recording surface curves; coiled spring box joint; torsion spring box joint; improved protecting retractor; spinal suspension tricycle; spinal suspension gymnasium for attachment to the ceiling; wire pad for attachment to spinal corset, to improve the appearance of the hopelessly deformed; combined spinal suspension balance and dynamometer; speculum for dilating abscess cavities; improved portable storage battery; the sphenometer; adjustable suspension crane for the electro osteotome; straight saw head piece for the electro osteotome; sectional saw head piece for the electro osteotome; splint for infantile spinal paralysis; combination apparatus for spinal caries and hip disease; improved trephine, with adjustable protecting sleeve; improved bone calipers; improved primary battery for the electro osteotome; improved club foot shoe.

From the foregoing, it will be readily understood that Prof. Roberts has led an intensely active professional life, for his contributions to medical literature and to mechanical therapeutics have been carried on in conjunction with the imperative demands of an extensive and rapidly increasing practice. As a result of his clinical studies and observations, he has elaborated a complete system for the mechanical treatment of chronically inflamed joints. In carrying out this work he has not been content with introducing his innovations to the profession, backed only by the assertion that they would be found to possess marked advantages over those that had preceded them. He has gone further than this, and supported his therapeutic ideas by a rational course of reasoning, based upon physico-physiological data, clinical observations, pathological findings, and what is known of the laws of growth and repair.

As his clinical observations, together with his other studies, led him into therapeutic paths widely separated from those generally accepted by the profession, it has been necessary for him to invent instruments for all of the principal joints of the body, which would enable him to practically carry out these ideas. No one who is not thoroughly familiar with the difficulty of procuring competent workmen to carry out novel mechanical ideas can appreciate the extent of this undertaking, to say nothing of the great expense involved in it, which he has independently borne.

Not only has he added largely to the resources of mechanical therapeutics, but it is believed that he is the first to introduce the use of instruments of precision in operative bone surgery, thereby eliminating at once a large number of sources of error which continually embarrass the surgeon.

His paper on the "Exploration, Excavation, and Illumination of the Interior of Bones in Any Part of the Body" is full of suggestiveness for the operative surgeon, and has attracted a great deal of attention and favorable comment.

He was the first to apply to bone surgery the teachings of Dr. J. Leonard Corning regarding the prolongation and intensification of the local anæsthetic effect of cocaine.

Among his inventions there are two that have been the result of long and persistent efforts on his part, and have nvolved the expenditure of a great deal of time, money, and experimental work. These are the electro osteotome and his woven wire spinal corset. Recognizing the necessity for an instrument that would divide bone with as much ease as the soft parts are divided with a sharp scalpel, and at the same time do away with the tearing and laceration incident to the use of the ordinary appliances for cutting bone, he has invented and perfected the electro osteotome. This invention was originally brought to the notice of the profession in October, 1883. with the successive improvements made during a period of three years, it has been so elaborated and perfected that it is to-day undoubtedly the most complete, effective, and manageable bone-cutting instrument in existence. Not only this, but an entirely new line of operations in bone surgery and improved methods of performing old operations are made feasible by the invention of the electro osteotome.

Prof. Roberts' woven wire spinal corset is also an invention which merits special mention in this sketch. It is original in conception, effective in practice, and elegant in appearance. It is the result of five years' experimental work in the construction of spinal supports. It is made directly over a cast of the body, and when removed from the cast retains its exact form. The use of this corset in the treatment of diseases, deformities, and weaknesses of the spine has yielded most satisfactory results. Being composed of an open wire mesh, it permits of the thorough ventilation of the body. The respirations are unimpeded by it, while its comfort, inconspicuousness, elegance, and durability all combine to make it a great favorite with all those who have a personal knowledge of its merits.

Recently, Professor Roberts has fitted up and thoroughly equipped, at his own expense, an experimental surgical laboratory, in which he is conducting a series of experiments in bone surgery upon the lower animals, with the ultimate view of adding to our resources for the alleviation of human suffering, the correction of unsightly deformities, and the more rapid termination of chronic bone diseases.

He has, during his nine years of active professional life, collected a vast amount of clinical data and other material, which it has been impossible for him up to the present time to elaborate in such a manner as to permit of its being brought to the attention of the profession. But with his rapidly increasing resources and unchilled devotion to the advancement of medical science, the profession will not have to wait long for further contributions.

Prof. Roberts is a man of medium height. He is quick in his movements, and possesses the rare qualities of untiring energy and indomitable perseverance. All his writings are characterized by originality and independence of thought, combined with simplicity of arrangement and lucidity of exposition. Believing that advancement in medical knowledge depends largely upon the avoidance of self-deception, he has disciplined himself to be a severer critic of his own work than is his most formidable professional adversary.

Toward those departments of inquiry which have for their end the relief of human misery and the cure of deformity, his mind is ever tending. His unremitting exertion in this direction is sufficient to have undermined a constitution set in an ordinary mould; but his strong body, his unstinted zeal, cheerful disposition, and overflowing enthusiasm carry him triumphantly over every obstacle that lies in his path. This is one of the most remarkable elements of his character, and the one that has, more than anything else, enabled him to tide over the difficulties that presented during his first years of professional life in New York. Though still a young man, he has won a reputation in the domain of mechanical and operative bone surgery that cannot any longer be confined within the narrow limits of a State or country.—*Va. Med. Monthly.*

HARVARD'S NEW OBSERVATORY.

THE munificent bequest to the trustees of Harvard College observatory by the will of the late Uriah A. Boyden, amounting to $230,000 or a little more by accumulation of interest, was made for the purposes of science in the department of astronomy, and definite application as then determined is mainly to be in the line of stellar photography. Preparations had been entered upon for the establishment of an observatory in some degree experimental at some point of high altitude in the State of Colorado.

The enterprise thus projected being a part of the work of the Harvard College observatory, is under the general direction of Professor E. C. Pickering, the head of that institution, but as a department or subdivision of the observatory work is placed in immediate charge of Mr. W. H. Pickering, the professor's brother, who becomes one of the official corps of the observatory.

These preparations are now completed and the work is entered upon. Mr. W. H. Pickering started for Colorado recently, taking with him fourteen cases, about a ton's weight altogether, of the most perfect apparatus known to science. Accompanying him were his two assistants, Messrs. D. P. Bartlett and H. E. H. Clifford, who have recently been in the service of the Institute of Technology, and who were graduates of that institution of the class of 1886. Professor Pickering has gone to Colorado, and will remain there some months until the proposed mountain observatory shall be located and organized.

This beginning is in itself an event in the progress of astronomical science, for the reason that the art of stellar photography, which has recently been making great advances, has never yet had opened to it so favorable a field for its exercise as that here at command, and for the reason that no equipment of apparatus, both in respect to quality and amount, comparable with that now to be put into use, is possessed by any other institution in the world. A considerable share of this apparatus is of the original device of the Messrs. Pickering, and the product of these few months of preparation, and therefore unique.

Nor are the merits of the case properly indicated without saying that, in the skill and experience of the director of the observatory as a practical astronomer and observer by the photographic method, and in the qualifications of the younger Mr. Pickering as a specialist in the photographic art in its scientific applications, the expedition has an equipment which gives peculiar and enhanced value to its material resources.

The significance of this undertaking is well understood among scientists, both in this country and others, near or distant. Professor Pickering has received letters from such resident in different mountain regions of Europe, at the Cape of Good Hope, and near the ranges of the Himalayas and the Andes, urging him to select a position in their respective neighborhoods for this important undertaking.

But it was some time ago resolved that the western continent shall be the scene of operations. The work to be done in Colorado is experimental in this particular, that by means of it the exigencies of such work in high altitudes will be ascertained, and all instrumental and other adaptations necessary can be made where the resources of Yankee civilization are close at hand. All being duly tested, the ultimate step will be taken in establishing a permanent observatory where those resources are not at command south of the equator in the Andes range.

Great interest has already been manifested among leading citizens of Colorado, and proffers of assistance of various kinds have been made. The headquarters of the expedition will be for the present at Colorado Springs, a town of importance, commercially and otherwise, on the main line of railroad extending from Denver to Pueblo. Its prosperity is in good part owing to the fame of its mineral springs, making it a social center of considerable dignity. Among the institutions is the Colorado College. Professor Loud, whose department in the college includes instruction in meteorology, has volunteered his assistance and advice in the pending enterprise, which will be of special value from his personal familiarity and exact knowledge of the region in desirable particulars. He is president of the Meteorological Society of that place.

The town has an elevation of about 6,000 feet above the sea. Positions of greater altitude are numerous at no great distance from the center, and the several heights increase as they become more remote, and find their maximum in the well-known Pike's Peak, which is several miles distant. At the peak is a station of the national signal service, which is in communication with the town of Colorado Springs. General Greely, the chief of that service, has proffered co-operation in the new enterprise, and will give it the advantage also of meteorological information derived from more distant points, but valuable for purposes of comparison.

The immediate search will be for conditions of atmosphere most favorable for photographic work in respect to clearness, steadiness, and equability of temperature. A considerable height is also essential. The peak is about 14,000 feet above the sea. Between the elevation of 6,000 and 14,000 the desired position will doubtless be found. The importance of height is in getting rid of the denser atmosphere which is productive of the red rays in sunlight. The more rarefied atmosphere abounds in the blue rays, which are the working elements of the photographer.

It may prove to be advantageous to locate the observatory near Leadville, which is 100 miles distant from the Springs, and has a railroad which ascends for mining purposes to a height of 11,000 feet. This will be of great service in conveying the heavy instruments. At the Springs the expedition will have to depend on mules for carriage. Whatever experiments are made near the Springs will, however, be of practical value at Leadville, as the atmospheric conditions are not materially different.

The instruments taken by Mr. W. H. Pickering comprise a new telescope of 12 inch aperture, made by Clark, of Cambridge, about a half dozen telescopes of smaller apertures, that is, of four inches or less, numerous appliances of new design, mostly for photographic work, and self recording barometers and thermometers.

At the establishment of Clark there is in process of manufacture a telescope of 13 inch and another of 10 inch dimensions, both being provided with photographic lenses. The 12 inch instrument already forwarded is for visual use. One of the unique appliances of the expedition is in the 13 inch telescope. The result of numerous conferences between the users and the makers of the instrument is that a modified or reversible lens has been introduced, so that the same instrument can be used alternately for visual and for photographic purposes. This in itself may be reckoned a triumph already achieved, which in the record must go to the credit of this expedition.

Though the Colorado observatory is for the moment to be classed as an experimental one, the real "objective point," as the military men say, being a permanent establishment south of the equator, there are reasons to hope that it will be taken up by the Colorado people in the interest of science and made a fixture in that State. The position, geographically, is an important one. There is no first-class observatory much nearer than 1,000 miles. The region is midway nearly between the Lick observatory on the Pacific and those of St. Louis and Ann Arbor.

The photographic plates will be returned to Cambridge to be worked up for results and for publication in the annals of the Harvard College observatory. It is not probable that observations will be continued in Colorado after cold weather begins, but the building and apparatus will be so secured against the weather as to be available in the early spring, and a long season for practical work will be assured for the next year.—*Boston Advertiser.*

A MATHEMATICAL GAME.

THE TAKING OF THE BASTILE.

There was recently sold in the streets of Paris a small cardboard box in which was pictured the figure shown in the annexed cut, and which contained seven black and seven red counters, along with a mathematical conundrum.

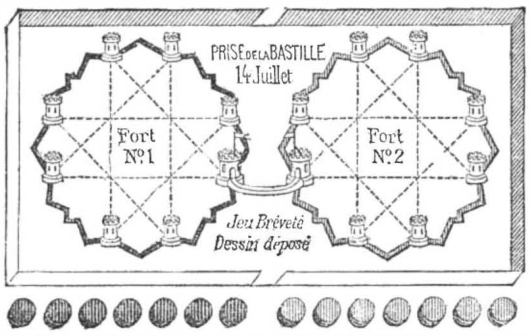


Fig. 1.—A MATHEMATICAL GAME.

This question, called the taking of the Bastile, consists of the four following problems: (1) To pass into the fort to the left the seven black counters (in following the dotted lines) through the door, P (Fig. 2), in such a way as to man the seven towers numbered from 1 to 7, and to leave the door free. (2) To pass the seven black counters from the fort to the left into the one to the right (in following the diagonal lines), and by entering through the door, P', in such a way as to man the seven towers numbered from 1 to 7, and to leave the door free. (3) To pass seven red counters into the fort, as in the first problem. (4) To remove one of the counters and make an exchange of the other counters that man the two forts, in making them pass alternately from one of the forts to the other, and always over the dotted lines.

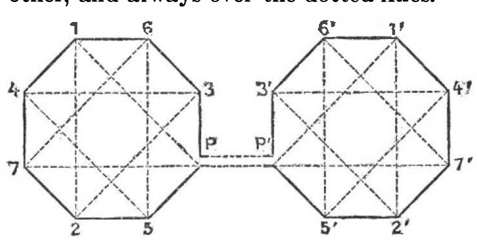


Fig. 2.—EXPLANATORY FIGURE.

It is to be understood that two counters cannot be simultaneously in the same tower, nor upon the same spot. The game is easily played by drawing the figures upon a sheet of cardboard, and using the red and white counters employed in the game of checkers. We shall observe in the first place that the third problem does not differ from the first, and the second differs only in direction, for the figure consists of two symmetrical parts.

In order to solve the first problem, we introduce a counter at 3 in following the route P 1 2 3, then another at 2 in following the route P 1 2, and finally a third at 1 by the route P 1; in all $1+2+3=6$ moves. We afterward introduce a counter at 4, through the route P 7 6 5 4, then one at 5, through the route P 7 6 5, one at 6 through the route P 7 6, and the seventh at 7, through the route P 7; in all $1+2+3+4=10$ moves. We have therefore filled the fort in 16 moves.

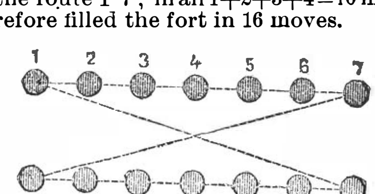


Fig. 3.—FIGURE OF THE SOLUTION.

We might have filled the towers 2, 1 first, and then, in the opposite direction, towers 3, 4, 5, 6, 7. This would have given a number of moves equal to

$$1+2+1+2+3+4+5=18.$$

If the figure embraced a large number of towers, we would divide the counters into two equal parts, according as the number was odd or even. One of these parts we would introduce in the direction P 1 2, and the other in the opposite direction. We should thus have the minimum number of moves.

In order to solve the fourth problem, we can always suppose that the counter removed was on tower 7', for were it otherwise it would be only necessary to make a few counters of fort P' to go back one row in order to free tower 7'. (*a*) This granted, we place upon 7' the counter that is on 1, and afterward move all the counters of fort P back one row, so as to free tower 7. (*b*) We place on 7 the counter of tower 1' and move all the counters of fort P' back one row, in order to free tower 7. (*c*) Finally, we repeat in succession maneuvers (*a*) and (*b*) until the exchange of counters has been made in the two forts.

The number of moves is 85, and if the polygon has n towers more than the door P, the number of moves will be $2n(n-1)+1$.

These rules are evident if we remark that it is possible to replace the figure given by the one shown in Fig. 3.—*La Nature.*

FROM LA NATURE.

The articles we give this week, entitled "The Principle of Inertia," "Soap Bubbles," "Physics without Apparatus," are from *La Nature.*

SOAP BUBBLES.

In my lectures on physics, I have often repeated the experiment of sending up into the air small soap bubbles filled with hydrogen. As well known, it is only necessary to give these bubbles a diameter of two or three inches to see them rise rapidly to the ceiling.

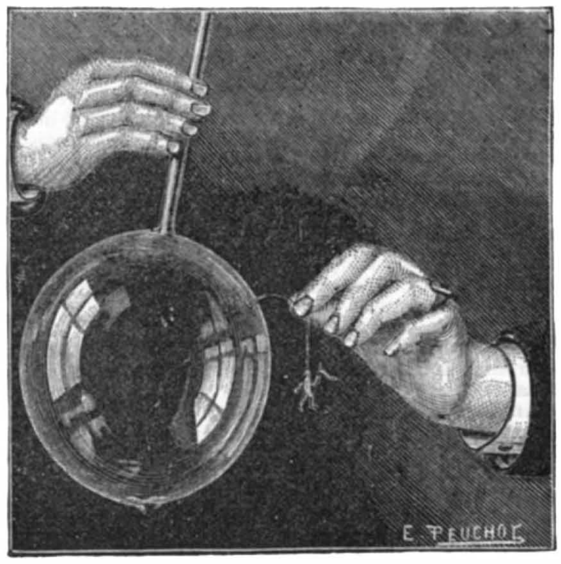


Fig. 1.

Fig. 2.

SOAP BUBBLES AND MODE OF AFFIXING A PAPER AERONAUT THERETO.

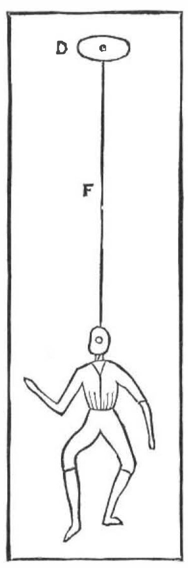


Fig. 3.—THE PAPER AERONAUT (ACTUAL SIZE).

This amusing experiment furnishes an analogue of balloons inflated with hydrogen or illuminating gas. I render it more instructive and more varied by bringing a lighted candle into contact with the ascending spheres, and making them burn.

The following is another experiment none the less interesting and much simpler for producing true hot-air balloons. Take a glass tube ¾ in. in diameter by 8 inches in length, or, if that cannot be had, make a tube out of writing paper, which will permit of easily obtaining bubbles as large as a man's head. Dip the extremity of the tube into a solution of Castile or other soap, and blow downward strongly and rapidly. The bubble will quickly increase in size, and the hot air injected from the lungs will soon cause it to rise. Without letting go of the bubble, follow its ascensional motion, gradually turning the extremity of the tube upward until the drop suspended from the bottom is reached. The last portion of the liquid will thus be made to flow over the sides, and the fully inflated balloon will only wait for the word "go," even if, as has often happened with me, it does not detach itself.

If the surrounding temperature is somewhat low, the bubble will burst at the ceiling. If the contrary is the case, it will slowly descend as soon as it has cooled a little.

On using tubes of different diameters, I have sent up much smaller bubbles; but the experiment becomes difficult with those of small dimensions. The paper tubes should be replaced by others when they have become soaked and soft. Glass tubes should be used if possible.

These experiments in sending up large soap bubbles by warm air decided me to attempt to affix to them a little figure of an aeronaut. I have succeeded in this several times, not without difficulty I confess, and I can affirm that the experiment succeeds when it is well executed.

A figure of a man is cut out of very thin paper, and is attached to a thread which is affixed by its other extremity to a small paper disk that is made to adhere to the soap bubble by simple contact, as shown in Fig. 1. On giving the glass tube a slight oscillation the bubble becomes detached and, after the manner of hot-air balloons, rises with its aeronaut (Fig. 2). In Fig. 3 I give the aspect and size of the paper image that I have succeeded in sending up with a large soap bubble. D is the upper disk of the paper, and F is the fine thread terminating in two knots that serve to hold it at the top and bottom.—*Prof. Escriche.*

THE PRINCIPLE OF INERTIA.

Experiments upon the principle of inertia are very numerous, and we have already described a large number. We now revert to the subject *apropos* of a communication that has been addressed to us by a correspondent, who writes as follows:

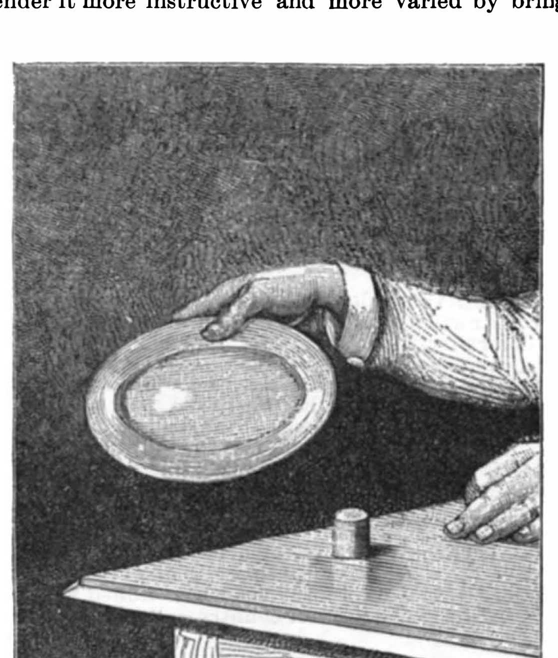


Fig. 1.

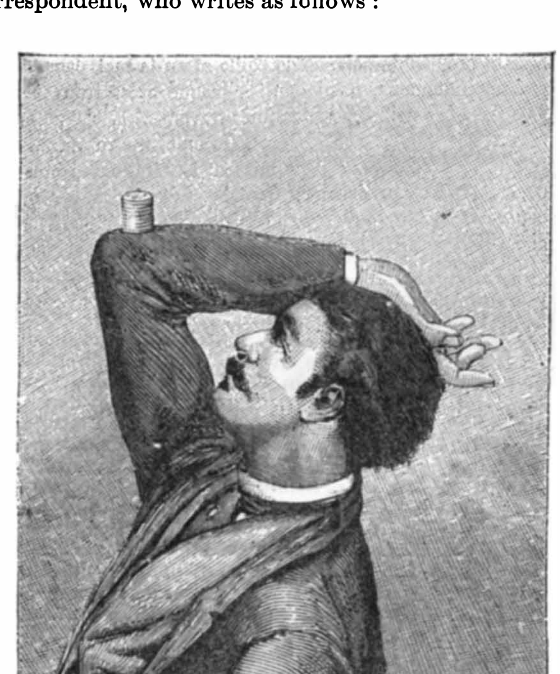


Fig. 2.

EXPERIMENTS UPON THE PRINCIPLE OF INERTIA.

Pile up a dozen different coins on a plate and propose to the persons round you to deposit them in the same order upon the table at one swoop. The uninitiated will try in vain. In order to succeed in doing this, lift the plate 12 inches above the table, lower it quickly 8 inches, and pull it toward you, and the coins, losing their support, will fall upon the table in their original position.

This experiment recalls another of the same kind that we performed in our youth. It consists in bending the arm as shown in Fig. 2 and placing a pile of coins upon the elbow, and then quickly throwing the arm forward and catching the coins in the hand. With a little practice and skill a person can thus catch with his hand a dozen superposed coins without a single one of them dropping to the floor.

PHYSICS WITHOUT APPARATUS.

The Boomerang.—Every one knows the Australian boomerang. It is a curved weapon made out of a piece of hard and compact wood which the Australian savages dexterously throw at any given object—enemy or game. After the boomerang has struck the object, it returns of itself toward the person who threw it.

Some fifteen years ago, Mr. Marey, of the Institute, published an interesting article upon this subject. The learned professor at that time wrote, without knowing it, a short chapter on physics without apparatus. We shall reproduce the substance of it.

A piece of cardboard cut into the shape of a crescent, with rounded horns, is laid upon the end of the finger, or, better, is held between the nail and the finger (Fig. 1) in such a way that its plane is slightly inclined on the horizon, at 45°, for example; then a smart fillip, given to one extremity, sends the crescent into the air, and at the same time imparts to it a rapid rotary motion. As the crescent starts, it has the appearance of a little revolving wheel. It makes its way forward in an oblique ascending position, then stops, and, without turning over, returns upon the same trajectory, if the experiment is a success, but oftenest falls back of, in front of, or at the sides of its starting point, and always in retrograding.

"Why," says Mr. Marey, "does the object preserve the inclination of its plane with respect to the horizon? Here intervene the notions that Foucault has given us concerning the preservation of the plane of oscillation of a pendulum and the plane of rotation of a gyroscope. Therefore, it seems to me that we should understand the phenomenon in this wise: The boomerang receives a double motion from the hunter—a rapid rotation and a general impulsion. The rotation obliges the apparatus to keep its plane, and it therefore makes its way obliquely in the air until the forward motion is exhausted. At a given moment, the boomerang revolves fixedly in a point of space, and then gravity causes it to fall. But since the projectile, continuing to revolve, keeps its inclined plane, the resistance of the air tends to make it fall parallel with the said plane; that is to say, to bring it back to its starting point."

Revolution of a Coin between Pins.—We shall terminate this article by describing another experiment, that has been sent to us by Mr. H. Gilly, Licentiate in Sciences.

Lay a coin flat upon a table, and seize it with two pins held at the two extremities of the same diameter. It may thus be lifted without trouble, and if the upper part be then blown against, it will revolve with great rapidity between the two pins as an axis. The annexed engraving (Fig. 2) shows the *modus operandi.*

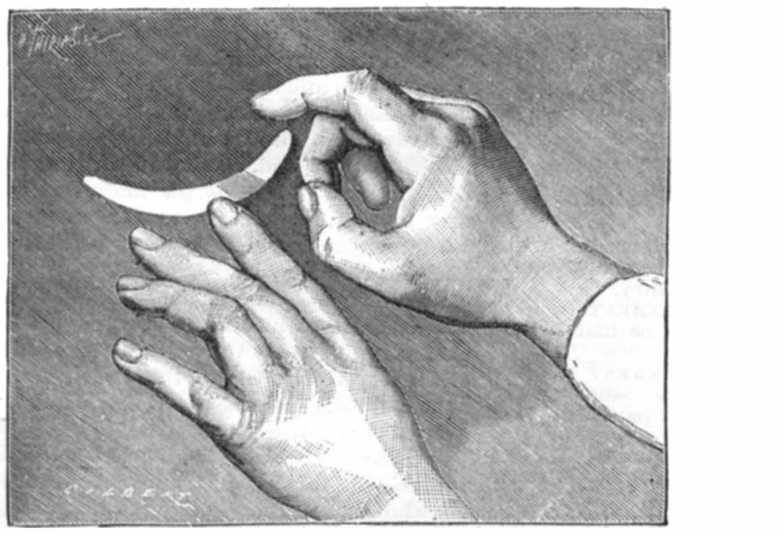


FIG. 1.—EXPERIMENT WITH THE BOOMERANG.

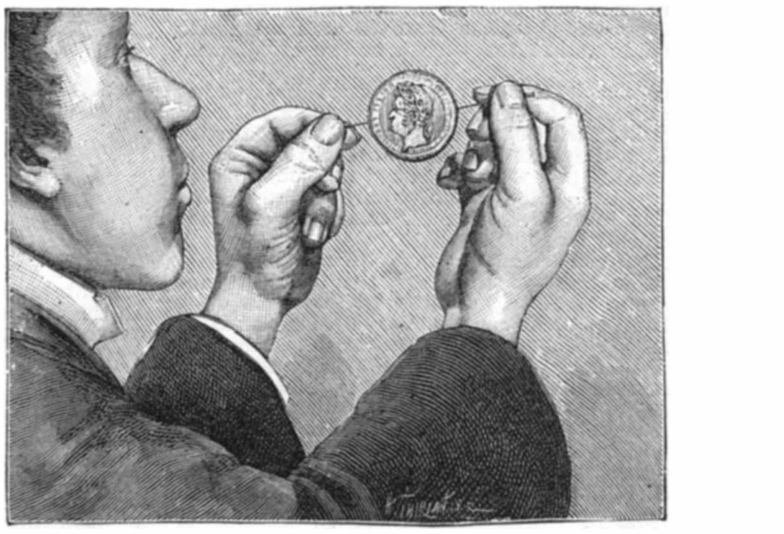


FIG. 2.—REVOLUTION OF A COIN BETWEEN PINS.

THE GIANT ARBOR-VITÆ.

(THUJA GIGANTEA.)

THAT the climate of Britain is peculiarly well suited for the development of this stately, fast-growing tree is certainly beyond a doubt, for although introduced only thirty-five years, many specimens of 70 feet and upward are to be met with. On this estate the annual rate of growth exceeds that of most other trees of which I have kept a record, twenty-four trees of this Thuja growing under ordinary conditions in the park having made an average annual growth of 22 inches; but even this is far surpassed by young trees of 8 feet or 10 feet growing in the home nursery. Unlike many of its American relatives—such as the Wellingtonia and Sequoia—this tree is never seen with a carrot-shaped stem, but gradually tapering throughout, and terminating in a leading shoot that is as thin and pliable as a whip handle. As an illustration of what is meant, we may say that the usual stem girth of a specimen 60 feet in height is 4 feet at a yard from the ground; whereas a tree of the Wellingtonia of similar height would in most instances be double that girth, and with a fast taper from base to tip. The branches are numerous, very irregularly arranged along the stem, and short in proportion to the tree's height, the branch diameter of a 50 feet high specimen standing alone being usually but 12 feet at the widest part. They are placed at right angles to the stem, or nearly so, very flexible, frondose, and with up-curved tips, and thickly covered with scale-like, finely pointed leaves, which are of a bright glossy green on the upper side, and distinctly glaucous beneath. Usually the cones, which are fully half an inch long, and resembling those of the common American arbor-vitæ, are produced in great abundance on the upper half of the tree, and when fully ripe impart, from their great quantity and tawny brown color, a by no means uninteresting feature to the tree. Judging from several hundreds of this tree planted over the estate, I should say that a deep, sandy, but moist loam suits this tree best; but yet it is far from particular as regards choice of soil, for we have numerous grand, rapid-growing, well-furnished specimens on deep, well-decayed vegetable matter, rough sandy soil, rocky *debris*, and in loam of a rather clayey nature.

Professor Macoun, of Ottawa, tells me that he has found this tree of largest size where growing in rather damp alluvial deposit; indeed, that it is almost unknown in the dry central plateau, but plentiful along the coast and lower parts of the rivers in its Canadian wilds. As to exposure, this Thuja is likewise to a great extent indifferent, although we must admit that even in a warm maritime country there is certainly a marked difference between trees growing in sheltered, sunny corners and such as are fully exposed to cold, keen-blowing winds, but even in the latter situation and when at a moderate elevation above sea level this tree does fairly well—better indeed than many other kinds that have been brought from the American coast. Even during the memorable Tay Bridge gale, when almost every tree suffered in some way or other, this Thuja remained unharmed, and I can safely say that during my ten years' sojourn at Penrhyn I have never seen a single specimen uprooted or a leader broken over by the wind. This latter is not to be wondered at, for I have more than once tied a knot on the leading shoot, so pliable and tough is the wood, and which, when released, springs back to its original position in a manner that is quite surprising.

The timber of this tree, as every one must know who had the privilege to behold the huge logs and nicely dressed smaller boards in the Canadian court of the late colonial exhibition, is of excellent quality, and highly prized by our American cousins. It is of a desirable yellow color, fine in the grain, easily worked, remarkably durable, and, what is especially valuable in any wood, light in proportion to its bulk. It must be understood, however, that we are now referring to timber produced in Canada; for as few specimens of this tree in Britain have reached a greater age than five and thirty years, the timber cannot be said to have attained to anything like maturity. From a specimen preserved here, and which was grown on the estate, it appears little different either in color or texture from that produced in its native country. The large butt of this tree referred to above, and which attracted a great amount of attention at the colonial exhibition, was no less than 21 feet in girth, and was taken from a tree 250 feet in height. Professor Macoun mentioned that this specimen might be considered as about the largest, but that, under favorable circumstances, the average dimensions reached by this stately, fast-growing tree are but little less.

In many instances the largest trees are hollow, and he likewise told me that it was not at all uncommon for several stems to issue from one crown, and that, like the spruce fir in this country, the outer branches of large specimens growing along the margins or open portions of the wood when they come in contact with the ground, take root and send up stout stems, thus imparting a curious appearance to such portions of the woodlands.

The northwest coast of the United States may be considered as the headquarters of this giant arbor-vitæ, and where it may be seen of all sizes from 40 feet or 50 feet to about 250 feet in height, and with stems girthing from 12 feet to sometimes as much as fully 40 feet, these being clean, straight, and of gradual taper throughout. Not only for its timber, but bark as well, is this tree highly valued in its native country, this being converted into mats, ropes, clothing, and other articles of domestic economy. As the timber works readily and takes a good polish, it is much sought after by the American cabinet maker, while most of the canoes made on Vancouver's Island are cut out of it, as also boats and ships; while for lasting qualities it surpasses most of the native timbers, for we were told that in repairing an old fort the only log found sound after twenty-one years' trial of those used for underpinning was that of an arbor-vitæ.

Some five years ago we planted experimentally a small piece of ground near sea level with fine, healthy 4 feet high plants of Thuja gigantea. These were planted at 16 feet apart, and the intervening spaces filled up with larch and several species of hardwood for removal at an early date. The soil being rather cold and damp, though artificially drained, was not well suited to the perfect development of this fast-growing tree, and, moreover, it was of a stiffish nature, in some places rapidly inclining to clay. To obviate the evil as much as possible the ground was well turned up at the time of planting, and the soil exposed for a short period to the ameliorating influences of a winter's frost. The plants have now become quite established and are growing rapidly; indeed, an examination of several specimens made to-day clearly shows that they will ultimately surpass both in height and stem bulk any of the other trees with which they are associated. It is evident from the narrow spread of the branches of this Thuja that it is eminently adapted for forest planting—at least that it will succeed better when grown thickly together than the majority of conifers, whose spread of branches is wide in proportion to their height. As it may be transplanted when of large size, this Thuja is of great value for filling up gaps in young plantations, and as its hardihood in this country is now quite an established fact, it bids fair to outrival many others for planting in even the coldest parts of the British Isles.

As a substitute for the larch, in conjunction with the Corsican pine and Douglas fir, this giant arbor-vitæ is well worthy of attention; indeed, it possesses qualities of which both these species are deficient, viz., in its being readily transplanted at all sizes up to 6 feet (want of this is the Corsican's greatest drawback); while its leading shoot never gets injured on rising above its neighbors, a fault to which we have found the Douglas fir particularly susceptible. The nursery management of this Thuja is also of the simplest description, it being very readily raised from seed, perfectly hardy in its younger stages, and at all times bushy, well rooted, and consequently sure-footed. It may, however, be well to say that ample space should at all times be allowed it while in the nursery borders and oft transplanting, as with other trees, induces the formation of numerous rootlets; therefore, to have nice bushy specimens the two requisites alone are plenty of room and frequent removals. As an ornamental tree Thuja gigantea holds a high place, its compact but easy contour, beautiful vivid green foliage, and well furnished appearance even when planted under what might be considered as disadvantageous circumstances rendering it a general favorite with the lover of hardy trees. Planted either singly or in masses of say five or seven together on the greensward and in close contiguity to clumps of the more stiff-growing pines, it never fails to attract attention and produce the most pleasing effect. Again, as a single specimen for planting at irregular intervals around the margins of plantations that are visible from park drives and walks, it is well suited, and quickly forms a neat tree of very pleasing appearance, and in such positions is of great value for lighting up our deciduous woodlands during the winter months. This handsome, fast-growing tree was sent to this country by Jeffrey, in 1851.—*A. D. Webster, the Garden.*

THE ANNATTO BUSH.

THE following information respecting the plant from which annatto is derived (*Bixa Orellana*) has recently been furnished at the request of the United States Government by the consuls of various districts in South America:

Para, Brazil (Consul Clayton).—The name "bixa," which has been given to a genus comprising four species of tropical shrubs or small trees belonging to natural order Flacourtiaceæ, is the native name of the Indians of Darien for one of the species, *Bixa Orellana.*

The Brazilian name of the plant is "urucuara," or plant bearing "urucu," the latter being the Brazilian name of the pigment known as annatto.

The species usually considered as producing annatto is *Bixa Orellana.* The species is a small tree or large shrub growing from 15 to 25 feet in height, bushy from the root or forming a simple stem. The leaves are broad, heart shaped, and pointed. The flowers, which are rose-colored or white, and somewhat resemble apple blossoms, are produced in large bunches on the ends of the young branches. The fruit is heart shaped, about an inch long, red or greenish yellow, according to the variety, and is covered with stiff prickles. When dry it splits in two, showing the seeds in a perpendicular row on each side. These seeds, which are very numerous, are embedded in a red, waxy pulp. I have never known the plant to be met with growing wild, though one often finds it many miles from any habitation, but it always marks the site of a former house or plantation.

The two species, or perhaps only varieties grown in Brazil, only differ in the color of the flower and fruit, which in the one are pink and red, respectively, while the other has white flowers and greenish yellow fruit.

The coloring matter seems to be of the same shade in both, and I have never seen any appreciable difference between the two kinds in the quantity produced.

The tree is cultivated in the whole Amazon valley, and is always seen around the houses of the Indians. It appears to attain a great age, but never becomes very large; the trunks of the largest I remember to have seen measured about eighteen inches in diameter at the base. The wood is light and considered of no value. The tree is subject to no diseases, is not attacked by insects, and birds do not eat the seeds. It grows freely in any soil, and no cultivation is necessary, except to shade and keep down the weeds around the young plants until they become well established. The trees must be grown in full sunshine, for if grown in the shade they do not bloom. Propagation is in Brazil effected only by seeds, and the trees begin to bloom when they reach the height of about 10 feet, which is in about three years from the time of sowing. In a cooler and drier climate, where growth would not be continuous, a far longer time would be necessary.

There seems to be nothing in the nature of the tree to prevent its being propagated by cuttings, which would probably root readily in bottom heat, and plants so obtained, following the general rule, would flower and fruit much earlier than seedlings. The plants also sometimes form many suckers around the parent, making a dense brush with many stems; when this occurs increase could be had by separation, and, as the roots are numerous, fine and fibrous, transplanting would probably be easy. In Brazil the fruit matures rapidly after flowering, and is ready to gather in about two months; if gathered as soon as matured, the tree at once makes fresh growth, and flowers and fruits anew. The practice, however, is to allow the fruit to remain on the tree until wanted for use; it dries, and as the capsule does not readily burst, the seeds remain long in good condition. Within a few months the tree is again in bloom, and usually one sees flowers and both immature and dry fruit on the tree at the same time. With the most careless culture two full crops can be gathered every year.

The preparation of the pigment is very simple. The seeds are macerated in water until the pulp, which is readily separated, is removed. The water is then passed through a strainer made of strands of palm to remove the seeds and fiber, and is then evaporated in the sun until the mass becomes thick. This mass is then rolled in leaves, producing roll annatto, or it is evaporated to dryness and made into cakes, producing mass annatto. Sometimes the seed, as taken from the pod, is simply dried for market, and forms what is known as "Urucu em grao."

The pigment is extensively used by the Indians in dyeing the threads of hammocks and by the wild Indians for painting their bodies, they mixing it with turtle oil or the fat of the peixe-bois (manatee). In Para it is sometimes used to give color to cooked rice, but I have never heard of its being so used on the Amazon. An infusion of the leaves drunk hot is considered by the Indians a remedy for jaundice.

An American gentleman who has explored the Amazon valley from Para to Iquitos, Peru, informed me that he had never seen in any of his travels any systematic culture of the urucu, and very little of the said article comes to this market from the territory through which he has passed. He noticed that each house or village had enough trees for the use of its inhabitants, but as far as he observed there was no disposition to make the urucu an article of trade. There is a small annual export from Para, which, I learn, comes from the Igaripe-Meri, distant about a day's voyage from this city, where there were formerly some plantations, but at present there is very little attention paid to the culture, and the plantations are neglected.

The quantity of annatto exported to the United States from this consular district during the last two years amounted to 27,435 pounds, and valued at $6,816.

Barranquilla (Consul Vifquain).—The annatto, called by the natives achiote, grows spontaneously around here, but none is raised for exportation from this consular district. It has no marketable value here.

I have a cluster of seeds before me. Many clusters are found on the bush, and each cluster has some twelve pods, and each pod contains about twenty-four seeds. It is not as heavy as wheat, but heavier than barley. I should say it weighs some 54 pounds to the bushel. I am told that one bush furnishes very often one bushel, a most enormous yield considering the size of the seed.

The cluster of pods reminds one of a cluster of cockle burrs. It has the same color, but, unlike this pestiferous burr, it is not persistent in its adherence.

The annatto grows in a dry climate as well as in a wet climate. At least, it looks as well now in the dry season (we have not had a drop of rain for four months) as it does in the rainy season, when it rains every day more or less, and rather more than less.

The natives use the annatto for coloring purposes. They are very fond of coloring victuals for the table here. It adds nothing, however, to their quality. The Indians use it as a defensive armor against the frisky and still more pugnacious mosquito. They crush the seeds "and anoint their naked limbs with the stuff."

Panama (Consul-General Adamson).—Annatto is not cultivated here, but is found in its wild state in all the coast districts of this republic, and it is not an article of commerce here.

My personal acquaintance with the plant leads me to believe that its favorite habitat is within fifteen degrees of the equator on the lower lands, in a soil of sandy loam, which is well irrigated for a part of the year, and that it is hardly probable that it would thrive in California, but that it might be expected to flourish south of the frost line in Florida.

Porto Rico (Consul Conroy).—The *Bixa Orellana* is disseminated through the whole island of Porto Rico. This shrub or small tree may be said to be here of spontaneous growth, for there is no instance of any regular plantation being established, nor of any careful cultivation being given to the plant.

The country working people are fond of having planted near their little homesteads two or three shrubs for the sake of the fruit, which they use as a condiment in coloring and seasoning their messes of rice and other food, in place of saffron or red peppers. The annatto plant in its natural or wild state is a scraggy, straggling bush, which often attains a height of 8 or 10 feet, but no doubt by proper cultivation and judicious trimming and pruning its condition and growth would be much improved, and its producing capacity would be greatly increased.

A very small quantity of annatto is exported from this province, either to Spain or the United States, but no other preparation is given to the article than merely drying the pods in a current of air under shelter from the sun, and then packing them in bags or barrels.

There are two kinds of annatto known to commerce, the "flag" and the "roll." The former is more abundant and more generally used, the second is scarce, and demands the higher price. Both are preparations from the same raw material.

The current value of the article in the crude state in which it is shipped is about four cents per pound.

As this plant is scattered and grows wild all over the entire island without any care being given to its culture, no true estimate can be given as to the cost of its production. It is gathered mostly by women and children, and disposed of in small quantities at the shops in exchange for provisions and groceries.

A DELICATE TEST FOR BISMUTH.

THIS test depends on the fact that a strong solution of potassium iodide added to a very dilute solution of bismuth sulphate produces a bright yellow color if only a small quantity of free sulphuric acid is present. By this process one part of bismuth oxide in 1,000,000 may be detected. Traces of bismuth in copper may be very conveniently estimated by this method. For this purpose the precipitated carbonate is washed with dilute ammonia and ammonium carbonate till free from copper, dissolved in a small quantity of dilute sulphuric acid, a few drops of potassium iodide solution added, and then a small excess of sulphurous acid to destroy the yellow color due to iodine which is liberated by the ferric sulphate present; the whole is then made up to 10 c. c. with water. For comparison a standard solution of bismuth sulphate (1 c. c. = 0·0001 gr. Bi_2O_3) is made by dissolving the requisite quantity of oxide in as little sulphuric acid as possible. About 2 c. c. or 3 c. c. of this solution are run off from a burette, 1 c. c. of a 2 per cent. solution of sulphuric acid added, and the whole diluted to 10 c. c. with water. A few drops of iodide of potassium solution are now added, and the color thus obtained compared with that of the mixture in the first tube.—*F. B. Stone, in Industries.*

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,

361 Broadway, New York, N. Y.

TABLE OF CONTENTS.