SIMPLE EXPERIMENTS IN PHYSICS.

BY GEO. M. HOPKINS.

A simple pendulum, which is a purely theoretical thing, is defined as a heavy particle suspended by a thread having no weight. The nearest possible approach to a simple pendulum is a heavy body suspended by a slender thread, as shown at A in Fig. 1, and although this is known as a compound or physical pendulum, its action corresponds very nearly with that of the simple pendulum. In the present case the pendulum consists of a heavy bullet or lead ball suspended by a fine silk thread. This pendulum, to beat seconds in the latitude of New York, must be 39·1012 inches long. That is the distance between the point of suspension and the center of gravity of the weight. This length varies in different places; for instance, it is 39·1948 at Hammerfest, and 39·0207 at St. Thomas.

A seconds pendulum is one that requires one second for a single swing, or two seconds for a complete to-and-fro excursion. The distance through which the suspended weight travels in one swing is the amplitude of the pendulum. Galileo's discovery of the law of the pendulum in 1582 is a matter of common knowledge. He observed the regularity of the swinging of a lamp suspended from the roof of the cathedral of Pisa, and noticed that, whatever the arc of vibration, the time of vibration remained the same. He also determined the law of the lengths of pendulums by experiment. He found that, as the length of the pendulum increased, the time of vibration increased, not in proportion to the length, but in proportion to its square root. For example, while in New York it requires a pendulum 39·1012 inches long to beat seconds, the length for two seconds would be 156·4048 inches. The length of a pendulum for any required time is found by multiplying the length of a seconds pendulum in inches by the square of the time the pendulum is to measure. In the above example, 39·1012 inches is the length of the seconds pendulum. Two seconds is the time to be measured. $2^2 = 4$. $39·1012 \times 4 = 156·4048$, the length of the 2 seconds pendulum. It is found that, barring the resistance of the air, all materials act alike when used for the weight of a pendulum. This is one proof of the uniformity of the action of gravitation on all substances.

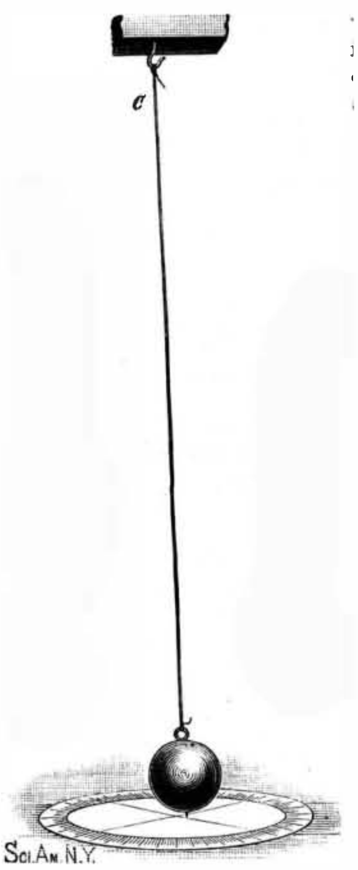

Fig. 2.

FOUCAULT'S EXPERIMENT.

In Fig. 1, at B, is shown a conical pendulum. It differs from the pendulum, A, only in the manner in which it is used; whereas the pendulum, A, is made to swing to and fro in a vertical plane, the pendulum, B, is started in a circle, as indicated by the dotted line. It is found by comparison that the pendulum, B, completes its circular travel in the same time that pendulum, A, requires to complete one to-and-fro vibration. The conical pendulum derives its name from the figure which it cuts in the air. The pendulum has been used to determine the figure of the earth, also to demonstrate the earth's rotation. Foucault's celebrated experiment at the Pantheon at Paris consisted in vibrating a pendulum having a period of several seconds over the face of a horizontal scale. While the pendulum preserved the plane of its oscillation, the scale indicated a slow rotation. This experiment may be repeated easily on a small scale in the manner illustrated in Fig. 2, at C. The ball, which must be a heavy one, is suspended by a very fine wire of considerable length, say from 10 to 20 feet. It must be started very carefully to secure the desired result.

To start it, a fine wire is tied around the equator of the ball. To this wire is attached a stout thread, by means of which the ball is drawn one side and held there until the pendulum is perfectly quiescent. The pendulum is then released by burning the thread. Some motion will be indicated in the course of a few minutes.

A pendulum capable of producing audible beats is often desirable. Fig. 3 shows a simple, well known arrangement for producing audible beats by the aid of an ordinary telegraph sounder. The ball, in this case, is suspended by a fine wire. Exactly under the point of suspension of the pendulum is placed a small wooden cup containing a globule of mercury, which touches a wire leading out of the wood and communicating with one binding post of the sounder; the other binding post is connected with one pole of the battery, the remaining pole of which is connected electrically with the support of the pendulum. The under side of the pendulum ball is provided with a platinum or copper point, which is capable of just touching the mercury globule as the pendulum swings. By this arrangement an electrical contact is made for each swing of the pendulum, and the sounder is made to click each time the circuit is closed.

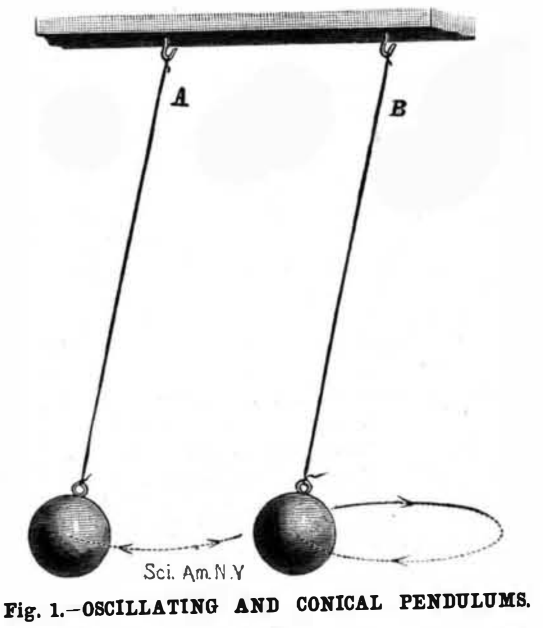

Fig. 1.—OSCILLATING AND CONICAL PENDULUMS.

By means of Kater's reversible pendulum, the length of a simple pendulum having the same time of oscillation as the compound pendulum may be accurately determined.

In Fig. 4 is shown a slightly modified form of this pendulum, in which the rod is formed of two parallel bars of wood, separated by blocks at the ends and provided with two swiveled cylindric rings, between which are placed two adjustable lead weights, held in place by crossbars secured to the weights by screws, and extending over the edges of the wooden bars. Below the lower swiveled ring are clamped lead weights, one upon either side of the bar, with a screw extending through one weight into the other. These weights are cheaply made by casting lead in small blacking box covers.

This pendulum is suspended upon a knife edge projecting from a suitable support, and the weights between the bars are adjusted until the time of vibration is the same for either position of the pendulum, it being reversed and oscillated first upon one of its rings as a center, then upon the other, until the desired adjustment is secured. Then the distance between the bearing surfaces of the rings will be the length of a simple pendulum which would vibrate in the same time as the compound pendulum.

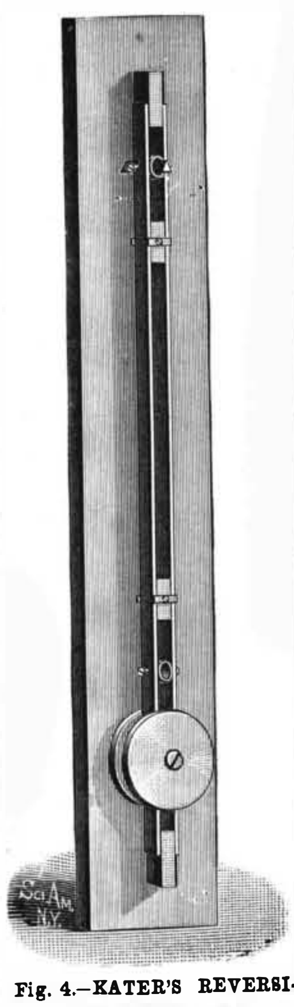

Fig. 4.—KATER'S REVERSIBLE PENDULUM.

A Petroleum Rocket Boat.

A novel craft, in the shape of a yacht, named the Eureka, 100 feet long, 12 feet beam, and 6½ feet draught, was launched from Poillon's ship yard in this harbor on the 27th ult.

This boat is to be propelled by the explosion of a gaseous mixture of air and petroleum, which enter at one end of two pipes arranged along the bottom of the boat, and discharge their contents under the water at the stern. The *N. Y. Herald* gives the following:

The mechanism lies in the afterpart of the yacht, and consists of a starboard and port cylinder, each 10 feet in length with an internal diameter of 20 inches. These cylinders are closed at the forward end, but open aft and in direct contact with the surrounding water, against which the gaseous products of successive explosions of fuel and air will issue. On top of each cylinder is an automatic valve that will be opened and shut by the force of explosion and exhaust.

Fuel in the shape of vaporized petroleum will be forced from a tank into the cylinders and ignited by an electric arrangement The electric spark will be generated between two electrodes, which will feed and regulate automatically.

The thermal principle that will propel the new yacht is one on which the combustion will yield a maximum amount of heat instantly without the necessity of draught; and as the conversion of heat energy into mechanical force is possible under a law of thermodynamics, there will be no limit to the speed of this class of vessel except the vacuum created by them in being forced through the water. From any point of view the system is purely scientific and simple, and whether it is equally as efficient will be demonstrated by future experiments. The most revolutionary part of the system is the novel method by which the mechanical force is applied to propel the vessel, and as the whole apparatus is motionless when in operation, no power is lost by friction or the overcoming of inertia.

Following are some of the advantages claimed by the inventor, Mr. John H. Secor·

The supply of fuel to the combustion chambers is automatic, and the combustion occurs in airtight chambers without draught.

There is complete combustion of fuel instantly following its introduction. This is succeeded by an instantaneous conversion of heat into power. All this occurs in the furnace or combustion chamber, and losses of heat are avoided on the one hand and losses of power, from friction, on the other.

The functions of the shaft and screw are also performed by the combustion chamber, and the room occupied by this is, for equal power, naturally much less than for boilers, engines, and shafts.

There is a saving of more than two-thirds of the cost of fuel and room required for its storage.

Such occurrences as disabled shafts and screws are impossible, and overpressure cannot occur under any circumstances. As the power is not stored, either as hot water or steam, this, of course, dispenses with "getting up steam" or "blowing off."

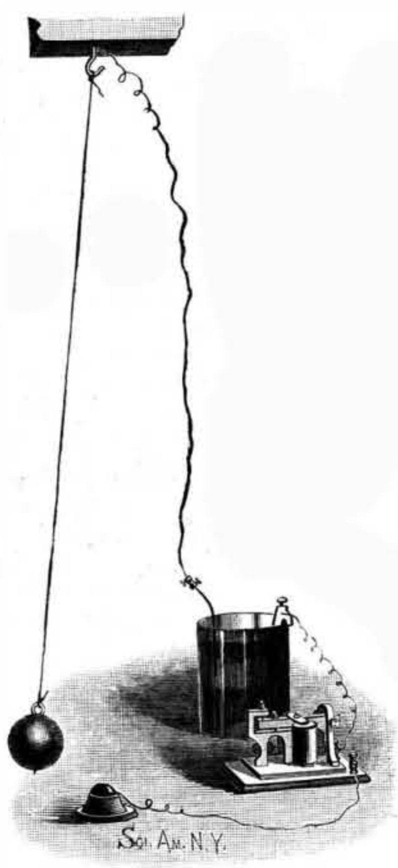

Fig. 3.—PENDULUM WITH AUDIBLE BEATS.

The power is applied in propulsion in such a way as to produce the greatest resistance from the water with the least disturbance of its inertia, *per contra* the greatest reactive effect.

In the largest vessel afloat, the captain from his bridge can stop the propelling force more quickly than an engineer can stop the engine of a launch, and in those of moderate size it is possible to maintain high speed for long distances.

We may add this vessel is a modification of Mr. Secor's boat, the construction and mechanism of which were illustrated and described in the SCIENTIFIC AMERICAN of July 24, 1886.

The Heating of Railroad Cars.

If some inventive genius will turn his attention to the contriving of a better apparatus for the heating of railroad cars by steam than is at present in use, he will stand a fair chance of making a fortune if he is successful. He will also save travelers from a great deal of suffering this winter, and thus earn the gratitude of the traveling public.

Owing to the new law forbidding the use of stoves in cars, the railroad companies have been obliged to resort for heat to steam, which is supplied by the engine. Railroad men admit that it will be almost impossible to heat long trains of cars by these means in the coldest weather, while any accident to the pipes, or any necessity that would take the engine away from the train, would leave the cars unsupplied.

The law prohibiting the use of stoves is a good one, but travelers on the railroad are already beginning to feel the effects of it in an uncomfortable way. Now, let the inventive mind apply itself to this problem and avert much discomfort.—*Evening Telegram.*

The Mitchell Monument.

An interesting address, delivered on the 16th Oct., by Dr. William B. Phillips before the University of North Carolina, describes the erection of a monument on Mitchell's High Peak, N. C., in memory of Elisha Mitchell, D.D., for thirty-nine years a professor in that university.

American scientists of middle age will remember that Professor Mitchell lost his life on the 27th of June, 1857, while engaged in measuring the heights of the peaks of the Black Mountains, in Yancey County, N. C. He had left his party about half way up the highest peak, with the intention of crossing the mountain alone and on foot, to visit an old guide with whom, on a former occasion, he had made the ascent. By some fatal mishap, the particulars of which must remain forever unknown, he fell over a precipice into a deep pool of water, and (probably rendered helpless by the fall) was drowned. His body was found after a careful search lasting ten days. It was interred first at Asheville, N. C., and from this place was subsequently removed to the top of the highest peak, where it was buried June 16, 1858.

Since that time, several attempts have been made to secure the erection of a monument to his memory on the spot where he had been finally laid to rest, but, for one cause or another, these plans came to nothing, and the breaking out of the war, followed by years of distracting excitements, caused the matter to be comparatively forgotten by the public. Recently, however, the surviving members of Professor Mitchell's family have become able to revive and carry out the project. Affection has paid the debt for which science and patriotism should have been equally liable. Dr. Phillips was charged with the execution of the work, and erected, during the summer just passed, a plain shaft of white bronze at the grave.

This peak, which now bears Dr. Mitchell's name, was first measured by him in 1844, and found to be 6,711 feet above sea level. A subsequent measurement, which he made in 1856, gave 6,700 feet. The United States engineers, in 1881–82, reduced this determination to 6,688 feet. It is beyond doubt the highest point in the United States, east of the Mississippi River. The ascent is best made from Patton's, on the Swannanoa River, from which point the distance to the summit is about twelve miles. Mere figures of altitude give no conception of the difficulty of the ascent, and especially of the transportation of heavy freight. Dr. Phillips' work was really a piece of engineering by the use of "main strength," worthy to be ranked with some of the feats of war times, in the movement of artillery over "impossible" ground.

The monument was cast by the Monumental Bronze Company, of Bridgeport, Conn., in nine sections, with interior bolts of copper and brass. The total weight is 900 pounds, the weight of the heaviest piece 140 pounds. As it now stands, it presents a pyramid, three feet square at the base and nine feet high.

"White bronze," as manufactured by the works above named, is almost pure spelter, containing only a few tenths of one per cent of ingredients other than zinc. After casting, it is treated with the sand blast, to impart a finely granular surface, closely resembling in texture and color light gray granite. It is practically weather proof, years of exposure only darkening somewhat its original hue.

A good deal of trouble was encountered in securing a firm foundation, the rock of the peak being a coarse and very friable gneiss. Two stones, weighing about 1,800 pounds, were united for this purpose with Portland cement. The structure is anchored to these by eight ½ inch copper bolts and four 1 inch zinc bolts, screwed into the first and third sections and secured to the stones by metal pourings. These anchors extend four inches into the bed rock. All the bolts are fastened from within, so that they do not show on the outside.

It was hauled by wagon from Black Mountain station, on the Western North Carolina Railroad, to a point two miles above Patton's, whence it had to be carried on men's shoulders ten miles further. In this distance, the grade for the first two and a half miles was about 800 feet per mile, and the average grade throughout was about 300 feet per mile. The transportation from the railroad to the top of the peak required thirteen men for three and a half days, and one boy and two oxen for one and a half days. When we add that the total expense was $46.96, we think it will be admitted that the money was well earned.

This monument is believed to be the highest of the kind in the United States. The grave of Mrs. Helen Hunt Jackson, near Colorado Springs, is said to be 8,500 feet above the tide, but is not marked by a structure of this kind, and the Ames memorial of stone, at the highest point of the Union Pacific Railroad, with an altitude of 8,247 feet, may also be ruled out of comparison, as presenting no difficulties of transportation or construction, being within a few yards of the railroad.

We must not omit, however, while we record the successful erection of the Mitchell monument, to recall the merits and services of him in whose honor it has been raised. At the time of his death, Professor Mitchell occupied, in the University of North Carolina, the chair of geology and mineralogy. He had been a constant contributor to *Silliman's Journal* for more than thirty years, and was a well known authority in many departments of science.

Born in Washington, Conn., August 19, 1793, he was, on his mother's side, a descendant of John Eliot, the "Apostle to the Indians." Graduating from Yale in 1813 (a classmate of Denison Olmsted, afterward his colleague at the University of North Carolina), he taught school on Long Island and Connecticut for three years, was a tutor at Yale College for two years, and finally, in 1818, found his life work at the University, where he labored thenceforward.

For nearly forty years his beneficent and powerful influence was felt in North Carolina, especially at the University, where, with Olmsted, Andrews, Caldwell, James Phillips, and others, he laid the foundation for sound and liberal learning. In 1832 he assisted Professor Caldwell in building at that institution the first astronomical observatory in the United States, and these two, assisted by Professor James Phillips, determined the correct latitude and longitude of Chapel Hill, and made observations on the fixed stars.

Professor Olmsted had started in 1819 the geological survey of North Carolina, the first in this country. Upon his removal to Yale, in 1825, Professor Mitchell took up the work, and was engaged in it until 1852, when it passed into the hands of Dr. Emmons.

These names of the great pioneers of American science must not be permitted to die out of our grateful recollection. How they would rejoice to-day, could they behold the tardy but abundant harvest of their sowing, in the awakening of the South to science and industry, the fulfillment of their hopes and prophecies, the march of organized armies of progress along the lines of their painful and solitary surveys!

If the Mitchell monument, looking down upon a busy and fruitful land, may symbolize the joy of these early toilers in the result of their labors, surely, on the other hand, the sons of the South will look reverently up to it as the type of those who gave their lives to her service, in the day of lowly beginnings, but lofty faith.—*Engineering and Mining Journal.*

Practical Work in a Practical School.

H. C. Spaulding, a graduate of the Institute of Technology, in a recent paper read before the Electric Club, tells how laboratory work and boiler and fuel tests are conducted at the Institute as follows:

Visitors are often surprised and amused at the transformation after seeing several rather dudesque young men enter the outer door and appear only a few moments later in flannel shirts and leather aprons ready for two or three hours at the anvil or forge or prepared for work in the mining laboratory. The mode of operation here is rather different from that in vogue in some institutions where the assistants do all the work and the students look on, making comments and taking notes of the operations.

In the Institute every man is obliged to go into matters for himself, dirt and such minor disadvantages being considered of no importance. The estimation of time, too, is considered of little moment, especially in case of advanced students, as it is a common saying among the boys that in order to meet the entire approbation of their own and their teachers' consciences they must study till three o'clock in the morning and then get up at midnight and begin again.

I recall with pleasure, not entirely unmixed, however, with other sentiments, several cold winter mornings when, with other poor wretches, I reported for duty at the Institute buildings at six A. M. Seven or eight of us were on for a boiler test, which necessitates being on hand at this unearthly hour.

In these boiler tests different stations are allotted to each student, as, for instance, weighing the coal, weighing the feed water, weighing ashes, etc., are recorded every five minutes during a ten hour run, and calorimeter tests are made two or three times during the day to determine the quality of the steam. Great care is taken that the conditions of the boiler at beginning and ending the tests shall be as nearly similar as possible. Toward this end the fires are drawn at about five minutes before the time of beginning and the steam pressure brought to the average point, the level of the water being also noted. At the given signal, a known quantity of fuel is put on the grate and the fire started.

At the end of the test, the boiler being as nearly as possible in the same condition as above, the fires are drawn again and the exact weight of the fuel thus removed deducted from that used in firing during the day. I think this method of carrying on the test will, for the actual value of its results, compare favorably with that recently proposed by a prominent educational gentleman in New England, who advocated using a small boiler upon platform scales for this purpose.

During the past year quite an amount of interesting work has been done in the electrical laboratory, including electrical and mechanical tests of some different makes of motors, also upon the efficiency of the Westinghouse converter. A new method has been used for testing the converters, which requires no measurements not obtainable with an alternating current.

Tests have been made upon incandescent lamps of different makes, including the customary ones, upon life and efficiency, and also upon the rise of candle power with increased voltage, and it is expected that the results of this latter line of work will be shortly in condition for publication. The specific inductive capacity of different materials has also been investigated, with some very curious results. Different makes of storage batteries have also been tested and compared.

Natural History Notes.

Effect of Climate upon Seeds.—According to Schubater, the majority of plants produce larger and heavier seeds at the North than at the equator, and this, according to him, is due to the long duration of the days of summer and to the long exposure to the sun. Beans carried from Christiania to Drontheim have furnished in the latter locality seeds that had gained sixty per cent in weight. Thyme from Lyons, planted at Drontheim, has gained seventy-one per cent in weight. On the contrary, the seeds of Northern plants, developed in more temperate climates, lose in weight.

Symbiosis of Alga and Sponge.—A very interesting case of what may be perhaps included under symbiosis is described by Messrs. Murray and Boodle in the *Annals of Botany* (p. 170). Under the name of *Spongodendron* and *Spongocladia*, two or three species of chlorospermous algæ have been described, which present a remarkable resemblance in outward contour and aspect to a digitate sponge. These have been examined carefully by the authors, who find that each alga is intimately mixed throughout its growth with a species of sponge bearing sponge-spicules. This growth does not appear to be accidental, since in each of the three species described a different species of sponge uniformly accompanies the alga, and the algæ are derived respectively from the Mauritius, New Guinea, and New Caledonia.

The Volcano Fish.—In the year 1803, Von Humboldt was fortunate enough to witness an eruption of Mount Cotopaxi, a well-known peak in the northern Andes, during which, among other products, a large number of fish were ejected. The inquiries immediately instituted and the investigations of more recent travelers have brought to light the astounding fact that, from time to time, though at irregular periods, fishes are cast up from the interior of the mountain during volcanic eruptions. The phenomenon is not confined to Cotopaxi, but has been observed also in other centers of volcanic action, viz., Tungurahua, Sungay, Imbaburu, Cargueirago, etc., all in the same range. From the craters of these volcanoes, or from fissures in their sides, it is an ascertained fact that fish are vomited to a height of some 16,000 feet above the level of the sea, and about half that height above the surrounding plains. The animals all belong to the same species, the *Argas Cyclopum*, as it has well been named. Nor is it a mere chance fish or two that find their way to the outer world through this strange opening. They are ejected in such countless shoals that, on more than one occasion, the fetid exhalations proceeding from their putrid bodies have spread disease and death over the neighboring regions.

As far as the external world is concerned, the fish is known to exist in some lakes on the sides of these mountains, and it is possible that these lakes communicate with reservoirs in the interior, where the preganadillas are generated, and thus find their way through the crater. But this is mere conjecture.

Puzzle to an Insured Man.

Nobody knows what an insurance policy means until he has been burned out. The proprietor of a Buffalo repair shop has been for years carrying a policy, says the *Courier*, not only upon his goods, but also upon articles left with him for repairs. These latter were specifically mentioned in the policy, which was a very broad instrument in its terms, and appeared "to be horse high, bull strong, and pig tight" in its power to protect the man who paid for it. It called for a larger amount than he would have placed upon his own property alone, and he was in the habit of telling people who left their property with him that it was amply protected. He was burned out the other day, and when he came to settle with the insurance people they declined to recognize his claim in behalf of property left with him for repairs, unless he had in each instance specifically agreed with the owner that its loss by fire should be made good, and charged a consideration therefor. They took this position on the ground that he was not otherwise responsible for the property left in his shop. They asserted that a watchmaker, for instance, is not responsible for watches left with him for repairs, unless he makes a special agreement to this effect with their owners and charges them for it. If this be true, it is a good thing for people generally to know. In the case referred to, the owner of the repair shop wonders what he has been paying for all these years.