SCIENTIFIC AMERICAN

A WEEKLY JOURNAL OF PRACTICAL INFORMATION, ART, SCIENCE, MECHANICS, CHEMISTRY, AND MANUFACTURES.

Vol. XXXVIII.—No. 6. [NEW SERIES.] NEW YORK, FEBRUARY 9, 1878. [$3.20 per Annum. [POSTAGE PREPAID.]

THE HORIZONTAL PENDULUM.

The most minute measurements known to science are made by an instrument which depends for its action upon gravitation. It is a pendulum suspended in an exceedingly delicate manner on the principle of the torsion balance, and the theory of its operation will be understood by the following simple experiment. In Fig. 3, R R represents a rigid rod which rotates freely on points at its ends. To the center of this is attached a shorter rod carrying the weight, W. If the rod, R R is horizontal, the weight will evidently hang vertically, and if pulled aside will swing to and fro like a pendulum. Now, if the rod, R R, be raised until it becomes vertical, as shown in Fig. 4, then gravity has no directing influence upon the arm and its weight, and they remain indifferently pointing to any point of the compass to which they may be directed. But if the rod be inclined never so little toward the horizon, gravity will act sufficiently upon the weight, W, to direct the arm, A W, into a vertical plane passing through the pivots of the rods, R R, and the more inclined this rod the greater is the force required to deflect arm and weight.

The instrument based on this principle, and devised by Zöllner, a noted German astronomer, in 1873, is represented in Fig. 2. It consists of a tripod with leveling screws supporting a vertical column, to which are attached two projecting pieces, C C'. To these are fastened two delicate watch springs, R R, which support the weight W. The latter therefore constantly exerts a pull on each of the springs, R and R'. A counterpoise at P balances the weight of W and its attachment. The weight carries a mirror, M, which reflects into a telescope a distant divided scale. By means of the screw, L, the instrument is made as sensitive as desired by approaching to the vertical the line connecting the points of attachment of the wires. The instrument is exceedingly sensitive to change of level, and the slightest movement of the screw, N, is sufficient to cause the weight to move away from the reader.

When the weight is at rest, the suspending wires without

Fig 3.

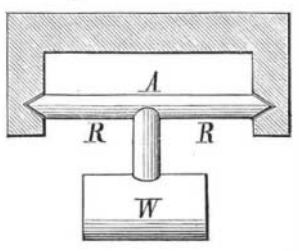
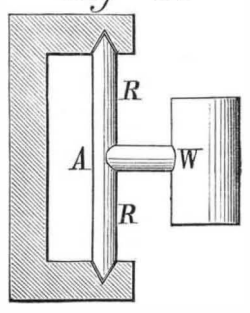


Fig 4.



torsion, the mirror, M, facing the south point of the horizon, and the sun or moon on the meridian, the position of the pendulum is at the point zero. When either celestial body is to the east of the meridian it pulls the horizontal pendulum in that direction until the body reaches the meridian, when no further deflective influence is shown. Then as the body moves over to the west, the deflection takes place in that direction. Zöllner found the instrument so sensitive to these actions that he could obtain from the observed deflection of the pendulum approximate values of the masses and distances of the sun and moon expressed in units of the mass and semi-diameter of the earth. He has also pointed out that if it is found practicable to determine accurately the position of the horizontal pendulum when on the meridian to one minute of time, then the velocity of the propagation of gravitation can be measured even if it has eight times the rapidity of the transmission of light through celestial space, or 1,480,000 miles per second.

In the large illustration, Fig. 1, is represented the modification of Zöllner's pendulum, invented by Professor Rood, of Columbia College, in this city, and adapted by him to the measurements of minute changes in the dimensions of solid bodies. He has succeeded even under adverse conditions in measuring to the $\frac{1}{3600000}$th of an inch, the smallest linear magnitude which has yet been grasped within the compass of science. In order to render the column, C, rigid, Professor Rood attaches to it the long inclined braces, E. At J is shown the head of a screw, and another similar one is on the other side of W. To these screws are fastened spiral springs, which confine the motion of the pendulum within narrow limits, and aid in leveling the same. Also to the pendulum is attached a wire bent in zigzags, which enters a box, H, filled with olive oil. This is so adjusted as to bring the pendulum to rest after a couple of oscillations, the oil box having an up-and-down movement by the mechanism shown. I is an index or pointer for adjusting the pendulum with regard to the scale, so that the mirror may be brought into position to reflect the zero or center of the scale into the telescope. Professor Rood suspends his pendulum by strips of copper foil. Only one of the leveling screws,

Fig. 2.

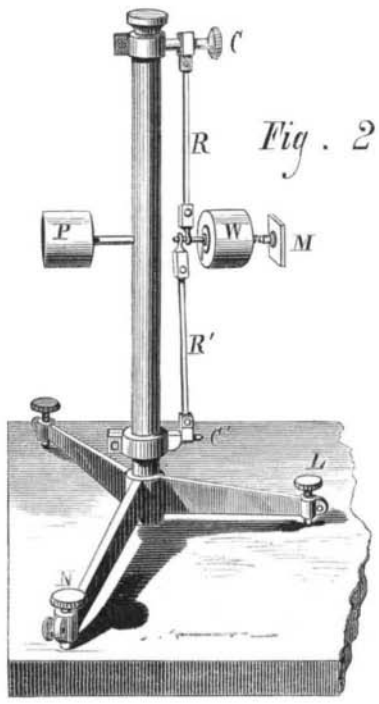


Fig. 1.

ZÖLLNER'S HORIZONTAL PENDULUM.

that at L, is shown in the figure. The arm, K, is connected with this, so that the screw can be turned through a very small angle. The levers attached to the two rear screws are marked R and N. One of these screws rested on the body whose changes in dimension were to be measured. It is evident that if one of these screws be moved up or down, the vertical plane, passing through the points of suspension of the copper foil bands, would be tilted, and hence the weight and mirror would swing into a new lateral position. The left hand screw attached to the arm, N, served as a micrometer. A scale placed under the telescope was reflected in the mirror and then read from the telescope, being thus magnified about 60 diameters.

To illustrate the delicacy of the apparatus, Professor Rood says that "children playing on an iron bridge 360 feet distant caused temporary deflection of one or two divisions, and similar deviations were caused by the lower notes in an organ in a neighboring church, the medium and higher notes producing no sensible effect." The general mode of experimenting is as follows: In all cases the micrometer screw (that moved by the lever, N) rests directly or indirectly on the body the change in the dimensions of which is the subject of study. It is first necessary to ascertain whether the different portions of the apparatus are at rest relatively to each other or approximately so. Afterward the value of a scale division can be obtained by repeatedly moving the arm attached to the micrometer screw by the aid of threads leading to the observer seated at the telescope. When this has been satisfactorily accomplished, the body to be experimented on is subjected to the desired influence, and the change in its dimensions noted; for example, the change in the longitudinal dimensions of a bar of iron, when magnetized, produces with this instrument a large and sudden deviation, and it is also possible to note the gradual increase in its dimensions, owing to the heat developed by the act of demagnetization. When it is recollected that with the best optical and mechanical means it has hitherto been hardly possible to measure quantities smaller than $\frac{1}{200000}$ of an English inch, the field which the use of the horizontal pendulum opens may be understood.

Our readers will find a very complete detailed description of Professor Rood's instrument, with directions for experimenting, in the SCIENTIFIC AMERICAN SUPPLEMENT, in which the article whence the foregoing particulars are taken will appear in continuation of the valuable series on the "Minute Measurements of Modern Science," from the pen of Professor A. M. Mayer.

MEDICAL PROGRESS IN 1877.

The London *Lancet* devotes a large portion of a recent issue to a very full summary of the advances made in medicine and surgery during the year just closed. Of these the most important are the following: M. Paul Bert has published an extensive work on the effect of variations of pressure on the body, and he shows that the observed effects of diminished pressure are exclusively due to a diminution in the tension of the oxygen in the air, and consequent predisposition to asphyxia; while on the contrary, increase of pressure up to three atmospheres occasions more active intra-organic changes, and when the pressure reaches five atmospheres the oxidizing processes either cease or become modified in such a way as to be inconsistent with the maintenance of life. Guttmann, Frickler, and Oertmann have demonstrated that the absorption of oxygen is independent of the mechanical acts of respiration. Richet has determined that when perfectly fresh the gastric juice contains only mineral acids, but that after standing for some time a kind of fermentation is set up in which much free organic acid is formed that on analysis proved to be lactic acid. It is believed to be beyond doubt that lactic as well as butyric and acetic acids are often either introduced into the stomach or are formed in it as a product of fermentation.

By far the most interesting discovery of the year in physiology is that made by Boll, that the retina possesses in health a peculiar red color, which is constantly being destroyed by the influence of light, and is as constantly being regenerated by the ordinary processes of nutrition. The "vision red" or "erythopsin," as its discoverer names it, attains its maximum after a night's rest and sleep, or when an animal has been kept for some hours in darkness; it is soluble in solutions of the biliaryacids and in glycerin, and probably plays a part in the production of the red reflection from the fundus of the eye seen on ophthalmoscopic examination, as well as in all probability in the ordinary acts of vision.

The most important progress in the department of pathology is that toward the establishment and diffusion of the opinion that minute organisms are concerned in the progress of acute infectious disease. Chaureau has shown that the horse is peculiarly receptive of the vaccine virus and is capable of reproducing it in remarkable purity and force.

In therapeutics salicin has been found to be a curative of ague, coryza, and some cases of neuralgia in which quinine has failed. Three cases of traumatic tetanus, one with a temperature of 108°, have been cured by chloral hydrate. Dr. Robert Bell, of Glasgow, has claimed for chloride of calcium remarkable power of controlling and curing many forms of tubercular disease. A large number of cases have been published showing the value of salicin, salicylic acid, and the salicylates in acute rheumatism and other febrile affections. In surgery Professor James Wood, of this city, has caused the reproduction of a new lower jaw bone, by the periosteum left in an operation for the removal of a jaw recussed from phosphorus.

Scientific American.

ESTABLISHED 1845.

MUNN & CO., Editors and Proprietors.

PUBLISHED WEEKLY AT

NO. 37 PARK ROW, NEW YORK.

O. D. MUNN. A. E. BEACH.

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VOL. XXXVIII., No. 6. [NEW SERIES.] *Thirty-third Year.*

NEW YORK, SATURDAY, FEBRUARY 9, 1878.

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THE SCIENTIFIC AMERICAN SUPPLEMENT

No. 110,

For the Week ending February 9, 1878.

Price 10 cents. To be had at this office and of all newsdealers.

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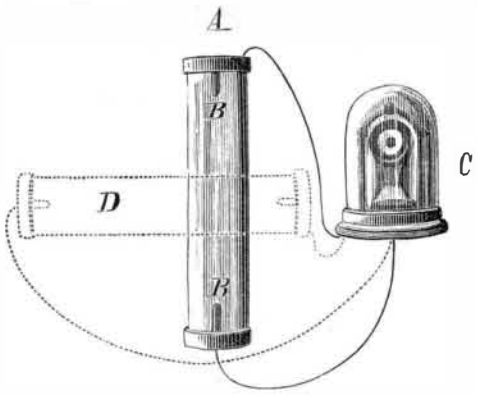
IS GRAVITY A MODE OF MOTION?

IN his 24th series of experimental researches Professor Faraday describes the experiments undertaken, the results of which, he says, though "negative, do not shake my strong feeling of the existence of a relation between gravity and electricity, though they give no proof that such a relation exists." In 1859, returning to the same investigations, he reflects upon the infinity of actions in nature, in the mutual relations of electricity and gravity, which would come in play: he pictures the planets and comets, charging themselves as they approach the sun; cascades, rain, rising vapor, circulating currents of the atmosphere, the fumes of a volcano, the smoke in a chimney, become so many electrical machines. Many more experiments were made by Faraday, but the results were still negative, and the experimenter did not accept them as conclusive. In this position the question remains to the present day; it may be, as Professor Jevons has suggested, that the effect was too slight to be detected, or it may be that the arrangements adopted were not suited to develop the particular relation which exists.

The force of gravity, while conforming on one hand to experience, is on the other a mysterious existence. We know that it is proportional to mass and utterly independent of present or intervening matter. In common with light, sound, and other influences emanating from a point, the law of decrease of its intensity is inversely as the square of the distance, yet, unlike the former, its action appears to be absolutely instantaneous.

The hypothetical ether which transmits light undulations which according to Herschel exercise a pressure of 17 billion pounds per square inch, and is harder and more elastic than adamant, is not influenced by gravitation as matter is, but its density and mechanical properties are modified by gravity in a way yet unexplained. Science thus far has stood silent before this mysterious influence, and there have not been wanting those who, like the late Professor Vince of Cambridge, have held that the force could be explained in no other way than by ascribing it to the immediate and ever present action of the Deity, an easy way of settling problems not wholly satisfactory to scientific minds.

The reader will now perceive the possible importance of an experiment which in place of Faraday's negative results has caused positive ones, and by which an electric current seems to have been produced by the direct action of gravity alone. Professor F. J. Pirani, Lecturer on Natural Philosophy and Logic in the University of Melbourne, writes to Professor Clerk Maxwell (who communicates the fact to *Nature*) with reference to the fact that a greater electric motive force is required to produce a given current between zinc electrodes in a solution of sulphate of zinc when carried upward instead of downward, testing the question whether a current should exist if two zinc electrodes connected by a wire are immersed in a solution of sulphate of zinc, the direction of the current being from the upper to the lower electrode. Professor Pirani used a glass tube, A, 18 inches long, filled with a saturated solution of sulphate of copper and closed with copper caps, B, with wires attached. This, on being attached to a Thomson static galvanometer, C, produced a deflection of 200 divisions when the tube was held vertically, the direction of deflection being reversed when the tube was reversed. When the tube after being held vertically was placed horizontally, as at D, the deflection diminished, and after several minutes the index came to zero.



Professor Maxwell has repeated the experiment, and considers that the temporary permanence of the deflection after the tube is placed horizontally indicates the possibility of something being shifted from end to end when the tube was inverted, but which remained where it was when the tube was only laid on its side.

Further verification of this experiment will be looked for with the greatest interest, as, if its present import be substantiated, the possible conversion of gravity into electricity places that force at once in the same category as light and heat, and indicates future possibilities in discovery over which now it would be idle to speculate. One, at least, may be the measurement of the velocity of propagation of the influence, and the means for determining this are probably already in existence, as will be seen by an examination of the horizontal pendulum, to the illustration and description of which we devote the first page of this issue.

STICK TO THE LAW.

The Commissioner of Patents has recently issued a circular to the Patent Office Examiners requiring them to see that specifications contain specific statements as to the state of the art prior to the applicant's invention, and that if a de-