MIXING OF FLUIDS—EXPANSION BY HEAT.

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The phenomena of diffusing fluids have already been alluded to, in an early article of this series. The mixing of thick silicate of soda solution with water was used as the illustration. To a suggestion from Mr. C. Trautwine, Jr., of Philadelphia, the experiment here illustrated is due. He observed that, in dropping whisky into glycerine, a peculiar effect was obtained. The whisky by its energy, due to falling, penetrated deep into the thick and heavier glycerine, and immediately tended to rise to the surface. In so doing, it subdivided the glycerine into veins, and seemed incapable of mixing perfectly with it.

In the illustration, a glass containing some glycerine is shown. From a height, in order to obtain impetus, alcohol is poured into the center of the surface. The effect described above is produced. If rightly done, the veins of subdivided glycerine will extend quite deeply into the center of the fluid, and produce a very curious and striking effect.

THE MIXING OF GLYCERINE AND ALCOHOL.

The subject of heat is susceptible of illustration by a number of experiments. Until reduced to the absolute zero, —273° Cent., the constituent molecules of all substances are assumed to be in intense and rapid vibration. This implies that they do not touch each other. By their oscillatory motion under the influence of the kinetic force, or objective heat, they are not allowed to rest touching each other. Hence, it follows that by applying more heat, their paths of vibration should be lengthened, and they should occupy more space. An *a priori* consideration would therefore lead to the conclusion that bodies increase in size as they grow hotter. Such is actually the case. The statement that heat expands and cold contracts is so old as to be known to all. It is a crude expression of a universal law.

To illustrate its universality, it should be shown experimentally as applying to all three states of matter—the solid, the liquid, and the gaseous. The expansion of solids shall first be considered here.

In general terms it is the most difficult of the three forms to use as the basis of a satisfactory experiment. Iron, per degree Centigrade, only expands 0·000012, brass 0·000018, and zinc 0·000029. Non-metallic substances are not so available as the metals, because they cannot, as a rule, be heated so highly. If a bar of metal is adopted, its expansion can only be shown by multiplying its movements very largely.

From the coefficients of expansion given above, it will be seen that zinc is a very suitable metal for the purpose. It is fusible at a rather low point, but not so much so as to impair it for experimental use where the temperature need not rise very high. The apparatus for exhibiting the expansion of metals is shown in the cut.

A wooden base, provided with two standards, is first constructed. It may be about twelve inches long and three wide. The standards are best mortised into the base, and glued or keyed so as to be free from shake, or they may be screwed or nailed directly to the

SOLDERING HEAD ON SCREW.

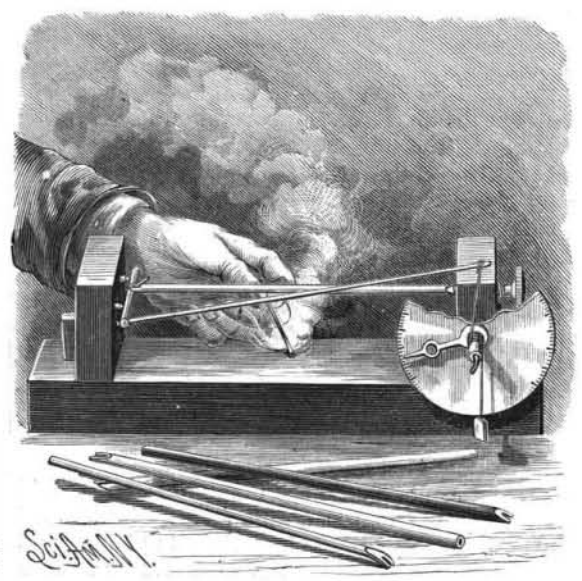
ends of the base piece. These uprights should be about four inches high. Through one of them, the left hand one in the cut, a hole is bored, near the top, through which a wood screw passes freely, screwing in and out. In the inner face of the opposite standard, at the same height, two sharply pointed pieces of wire (about one-sixteenth inch in thickness) are inserted, whose points project about an eighth of an inch from the wood.

The rod or piece of metal to be expanded comes next. Several are shown lying in front of the apparatus. A perfectly straight piece of brass, copper, or iron wire, or a corresponding rod of zinc is needed. The piece should be of slightly less length than that of the space between the standards. One end is filed off square, and a slight excavation is drilled or punched in its center. This is to receive the point of the wood screw. The other end is filed off obliquely, and a slit filed in the center axis of the rod. If the rod is very thin, less than a quarter of an inch, its end may also be slightly upturned, so as to produce a larger oblique surface. One of the pieces is shown thus constructed. In any case, a shape is given the end somewhat similar to that of the claws of a carpenter's hammer.

A short piece of wire has two holes punched or drilled in its surface, to receive the two points projecting from the right hand standard. Another very fine hole is drilled almost or quite through its center, in which a pin about the diameter of a ladies' hair pin is soldered. This pin should project a quarter of an inch, and should be about 135° from the two holes, as referred to the circumference of the wire. Finally, in the end of this short piece of wire another hole is drilled, and the long arm seen in the drawing is soldered therein. The experimental rod is placed in the position shown, and adjusted by screwing in or out the screw until the least motion affects the movements of the long index wire. Now if the rod be heated, it will expand, and raise the index wire perceptibly.

To still further multiply the extent of motion, the index attached to the left hand standard is provided. A wire axis is thrust into the wood. A thin tube, which may be of glass, is placed over this axis, a paper index is secured thereto by sealing wax, and the end of the wire is bent to secure all. If desired, a graduated dial may also be pasted to the standard. A thread is attached to the end of the wire index, is carried three or four times around the tube. At its end is a small weight.

By the wire index every movement of the rod in the direction of its length is multiplied, perhaps eighty or a hundred times. This, by the paper index, is again multiplied probably twenty times, giving a total increase of motion of two thousandfold. Hence the sensitiveness is very great. A match held under the rod will produce a visible movement in the index, while a candle or alcohol lamp will produce more than a full rotation of the index.

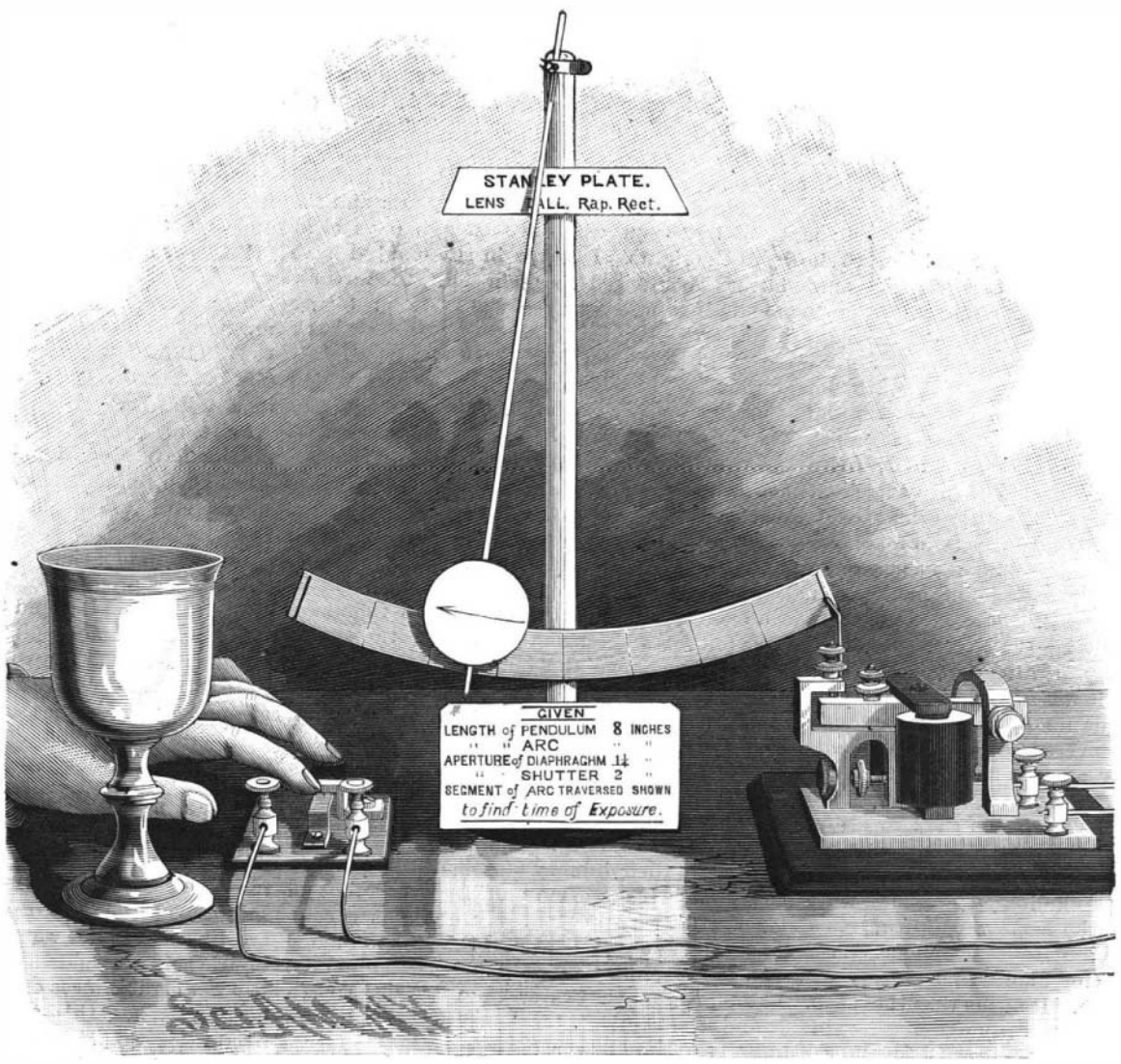


APPARATUS FOR ILLUSTRATING THE EXPANSION OF METALS BY HEAT.

The soldering is very easily done. A little hydrochloric acid is neutralized with zinc. The places to be soldered are cleaned and filed up bright, and a little of the "soldering acid," as it is called, is placed on them with a wire or a match. On heating one of the pieces in an alcohol lamp, with a bit of solder resting on it, the solder will melt and flow over the metal. This is done to both pieces separately, and afterward they are heated until the solder melts, and pressed together while held in the flame, removed, and allowed to cool. In the cut the operation is shown of attaching a head, which may be a copper cent, to the wood screw, to facilitate its manipulation. After tinning or coating with solder one side of the cent and the screw head separately, the screw and cent are placed as shown, are heated until the solder melts, and allowed to cool, when the union will be secure.

PHOTOGRAPHY OF A MOVING PENDULUM.

We represent in the cut accompanying this article an interesting achievement in photography. It is not only of value in itself as a perfect production of the art, but is very suggestive. It opens the question as to how much movement can be allowed to an object which shall not be detected in the blurring of its image, and also as to the relation between the distance, speed of object, and time for instantaneous exposure in photographing a moving object. Thus the one-hundredth of an inch is a distinctly visible quantity. A movement during the time of exposure which would, on the plate, produce this amount of displacement would tend to cause a blur. By one high authority the amount allowable is placed at 1-10 millimeter, or the 1-250 of an inch. It is uncertain how far this can be accepted as an absolute law.



PHOTOGRAPHY OF A MOVING PENDULUM.

If a moving steamer were photographed so as to be reduced to 1-1000 of her size, a displacement on the plate of 1-250 inch would represent on the part of the steamer a movement of 1000-250 inches, or four inches. At a speed of 15 miles an hour, this would occupy a period of 1-66 second. This reduction would represent the City of Rome as a little over six inches long.

In photographs of distant objects, there would be a certain difficulty in determining the blur. The grain of the paper would tend to conceal it. When a near object is photographed so as to be reduced to one-half only of its natural size, any displacement in the time of exposure is much more easily detected. It is such subjects that test most rigorously the limitations of the photographic art as affected by the shutter mechanism and sensitiveness of the plate.

The cut represents almost of full size a photograph of a swinging pendulum. It was taken by Dr. J. J. Higgins, an amateur photographer of this city. The conditions were as follows:

The pendulum was eight inches long as regards the distance from its point of suspension to its center of oscillation. Thus its period for small arcs would be about 0·4 sec., and for a longer arc such as indicated by the divided circle a very little more. It was held at one extremity of the graduated arc by a catch attached to the telegraphic sounder, so as to be released when a current of electricity was passed through the magnet. In the circuit with the sounder were included a key, a resistance coil, and an electrical detent of similar character to the sounder, for holding and releasing the shutter of the camera. The paper arc was divided into inches, and the general data of the experiment were written on the cards seen attached to the standard. The apparatus was set upon the roof of Dr. Higgins' residence. To make the print a certificate of its own authenticity, a goblet of mercury was placed by the side of the apparatus, and was photographed with it. This proved that the table was level. Otherwise, by inclining the apparatus, the pendulum could be taken by a time exposure in any desired position. At the upper end of the rod, two threads were used for suspending the pendulum. This precluded the possibility of the pendulum being mechanically held to one side, as it would be impossible to do this and keep the threads aligned with the rod. The camera was then placed a short distance from the apparatus, focused, the shutter detent arranged, a mirror was placed so as to reflect the sunlight directly upon the pendulum, and all was ready.

A touch of the finger on the key released both shutter and pendulum. The pendulum swung down, passed the lowest point of its arc, consuming very nearly ¼ second in the journey, and just as it was rising on the opposite side was photographed. The sharpness of the image is surprising. Absolutely nothing can be detected to indicate the motion of the pendulum. The length of the pendulum is known; the divisions of the arc can be reduced to degrees, so as to give its angular displacement, and thus we are in possession of the data necessary to arrive at an idea of the time of exposure.

The pendulum in its journey from starting point to the place where it was photographed had spent about ¼ second. It was at this point moving at the rate of 25·8 inches per second. Taking the reduction as one-half, which is not far from the truth, and allowing for a displacement of image on the plate of 1-200 inch, this would give for time of exposure $\frac{1}{12{\cdot}9\times200}$ second or 1-2580 second. For Mr. Muybridge's exposures the time of 1·500 of a second has been claimed. Mr. E. J. Marey, who in France has done the most important work of the last few years in photographing moving men and animals, has used a regular exposure period of 1-2500 of a second. Dr. Higgins, therefore, seems to have about reached the same limit, for when the sharpness of the image is considered, it is not easy to admit a greater displacement than that used in the calculation.

Again, it is necessary to distinguish between the efficient period and mechanically opening period of a shutter. Little effect is produced upon the plate until the shutter is partly open, and the light ceases to a great extent to act before the shutter is fully closed. The exposure, however, was wonderfully short. When the nearness of the object to the camera is taken into account, the perfection of the photograph produced is very remarkable.

Hydraulic Jack Patent.

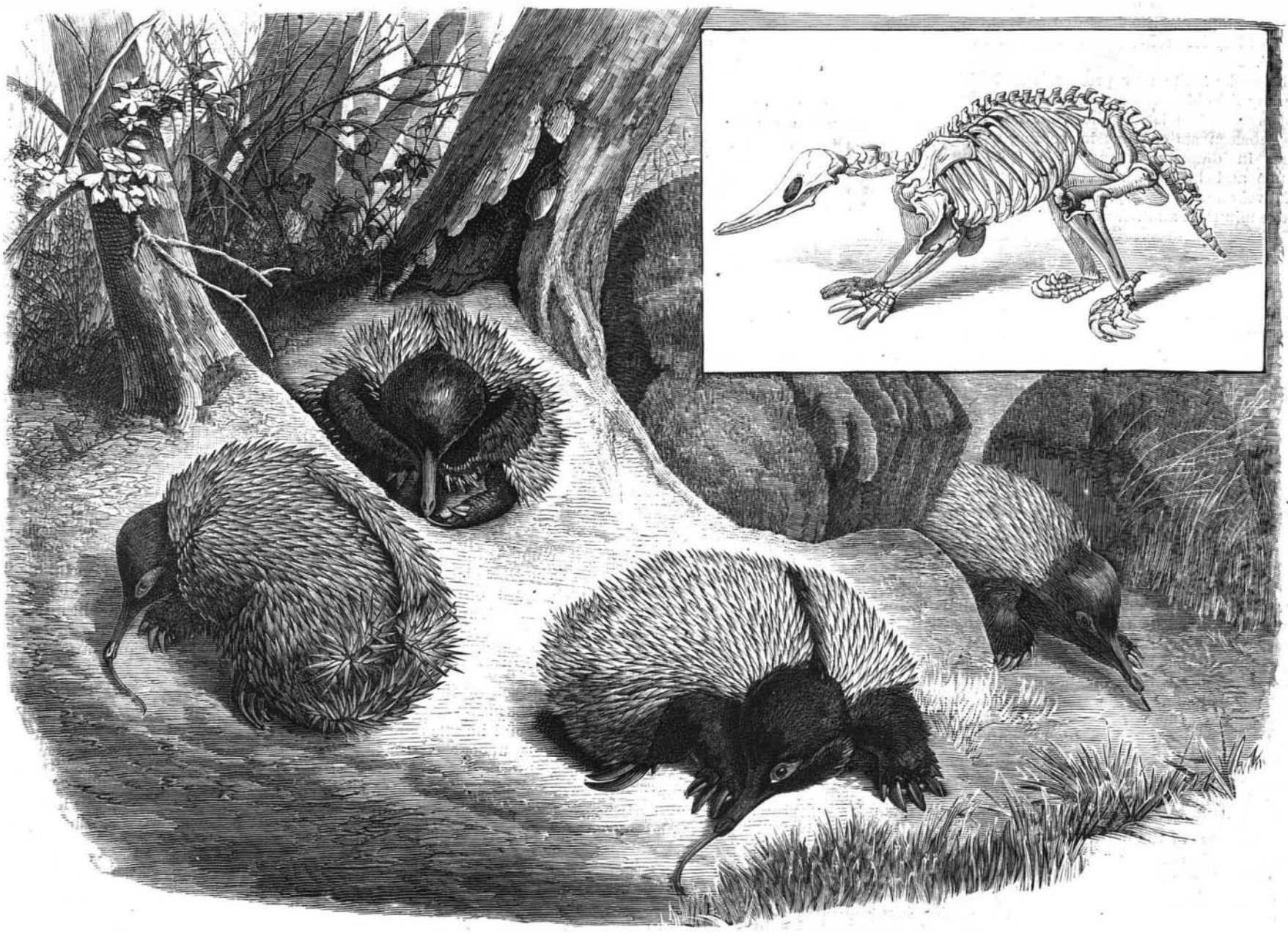
In the U. S. Court, Southern District of New York, in the case of Richard Dudgeon *v.* Watson & Stillman, for infringement, Judge Coxe sustained the plaintiff's claims and granted an injunction. The defense was want of novelty and non-infringement. The Judge in his opinion describes at length the workings of hydraulic jacks, and says there is no doubt as to the infringement of the patent, as the jack made by defendants works in substantially the same manner.

SOME one truthfully asserts that it is cheaper to get a good engineer and a good engine than to procure an inferior quality of both articles.

THE PORCUPINE ANT EATER.

An important question in natural history can now be answered. There are egg-laying mammals. This fact, which has long been believed by scientists, has finally been proved, and the link between mammals and birds, which, according to the saying that "Nature makes no jumps," must necessarily exist, has been found. It is worthy of note that Darwin was interested in this question.

August 25, 1884, Dr. Wilhelm Haacke, former assistant of Haeckel and Director of the South Australian Museum in Adelaide, discovered that the porcupine ant eater (*Echidna hystrix*) laid eggs, and the same discovery was made a few days later by W. H. Caldwell, a young English naturalist who went to New Holland to study the development of animals of the duckbill species. The anatomical construction of these animals and their position in the zoological system has been a subject of discussion among naturalists, but they have finally been classed as mammals. The particular animal to which we wish to call attention (see accompanying cut, taken from the *Illustrirte Zeitung*) is the porcupine ant eater (*Echidna hystrix*). It is the



THE PORCUPINE ANT EATER.

smallest of the monotremes, and reminds one of the porcupine. Its body is plump, and its short legs are each provided with five strong toes armed with sharp nails, well adapted for burrowing. Its beak resembles closely that of the woodcock, being thin and tube-shaped. The mouth is very small, only large enough for the passage of the worm-like, rough-pointed tongue, which can be extended some distance beyond the beak and is used for drawing in food (ants and other insects). No ears are visible, but there are hearing passages, which can be opened and closed by folds of skin. The upper part of the body is covered with black, pointed quills, the roots of which are surrounded by short hair, and the head, legs, and other parts of the body are also covered with hair.

This ant eater lives in mountainous districts and in high, dry woods in South Australia, where he burrows under the roots of the trees. In his hole he makes a nest which he lines with parts of plants. To protect himself from an enemy, he rolls himself up like a porcupine.

The Northwestern Miller, of Minneapolis, Minn., is a weekly publication which has attained a deservedly high position as a representative of the milling interests of the country. It celebrated the holiday season this year by issuing an unusually attractive number, a prominent feature of which was the presentation of pictures of a large number of leading members of the trade.