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.

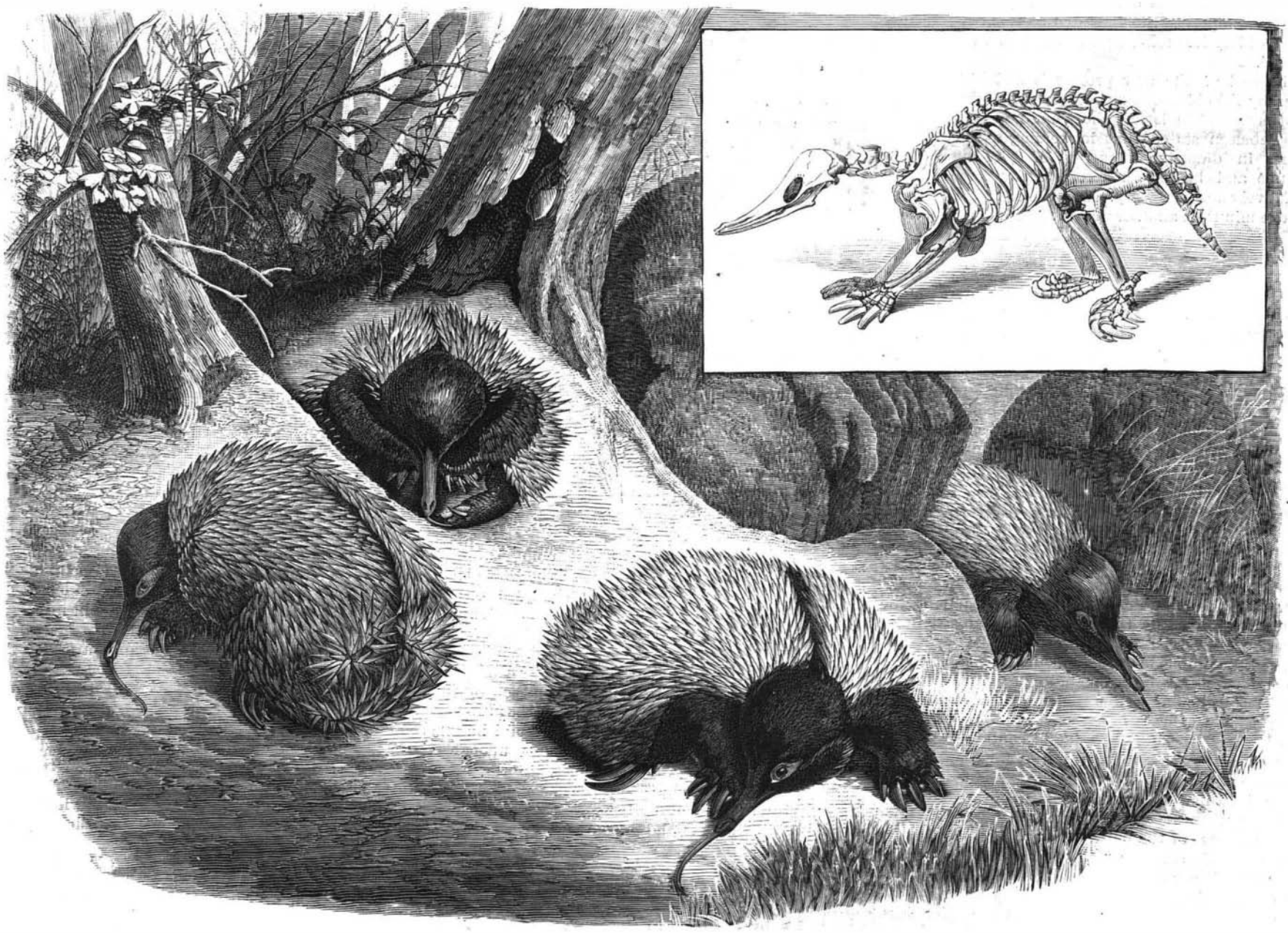
In the U. S. Court, Southern District of New York, in the case of Richard Dudgeon *v.* Watson & Stillman, for infringement, Judge Coxe sustained the plaintiff's claims and granted an injunction. The defense was want of novelty and non-infringement. The Judge in his opinion describes at length the workings 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.

Welding by Electricity.

Recently, at the Institute of Technology, Boston, Professor Thomson, of the Thomson-Houston Company, of Lynn, made known to the public his new and remarkable method of welding, by which a broken bar of metal can be easily reunited, or bars of different metals welded together; and those materials which previously resisted welding most strenuously are now joined with ease, while those previously easily welded remain the same by the new process. Differences in specific electrical and heat conductivity are the properties which are most troublesome. The method consists in simply forcing the ends to be welded together tightly and passing a sufficiently powerful current of electricity through the joint. The resistance raises the metal to a welding heat, and the pressure makes the joint. The speaker enumerated some of the practical results obtained personally within a recent period. Iron and copper wires of varying dimensions have been joined end to end. Steel or iron bars nearly an inch in diameter have been solidly welded together, and steel has also been joined to brass. A copper rod nearly one-half an inch in diameter has been welded, requiring a current of 20,000 amperes. Steel pointed tools may be cheaply made of inferior metal, and new points welded on as desired.

The cost of the new process is uudoubtedly less than by the old method of forge and hammer, while the time required is very short and no heat is wasted. Mr. Thomson stated that in welding a steel bar 1½ inches in diameter, a current of 6,000 amperes in volume and having an electromotive force of one-half a volt was necessary. The use of 35 horse power for one minute is another way to state it.

SCIENCE IN TOYS.

II.

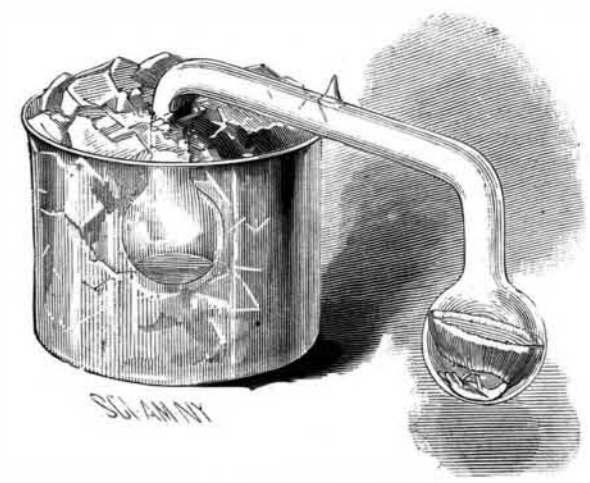
The pulse glass, shown in the annexed engraving, is due to Franklin. It consists of two glass bulbs, formed on opposite ends of a tube bent twice at right angles, the system being partly filled alcohol or ether, the air having been expelled by boiling the inclosed fluid before sealing the tube. When the bulb containing the liquid is held in the hand, and the tube is placed in a horizontal position, the rapid evaporation of the liquid by the warmth of the hand creates a pressure which causes the transfer of the liquid to the cooler bulb. The quick evaporation of the liquid adhering to the sides of the now empty bulb increases the pressure, and causes a rapid ebullition of the liquid in the full bulb, and at the same time carries off the heat to such an extent as to produce a very decided sensation of cold.

PULSE GLASS.

When the bulb is held at an inclination of about 40°, the liquid pulsates from one bulb to the other. The expulsion of the liquid from the bulb in the hand produces cold, which is quickly dissipated; and when equilibrium is restored, the liquid contained by the tube condenses the vapor in the empty bulb, and enters that bulb, to be again expelled as before.

The instrument operates continuously and very regularly when placed in a horizontal position upon a table, with one of the bulbs in the vicinity of a lamp, that is, within eight or ten inches of the flame, the other bulb being placed as far as possible away from the flame and shaded.

Wollaston's cryophorus is similar to the pulse glass,



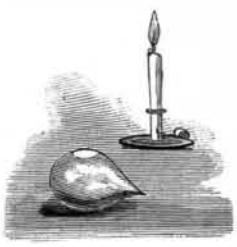
WOLLASTON'S CRYOPHORUS.

the only difference being that the tube connecting the two bulbs is made much larger, to avoid choking by ice, a thing sure to occur when the tube is of small diameter—the water vapor which is drawn toward the empty bulb (in a manner presently to be described) being condensed and frozen on the walls of the tube to such an extent as to entirely close it.

The cryophorus in process of construction is partly filled with water, which is boiled in the bulbs before sealing, to drive out the air. When the empty bulb of the apparatus is placed in a freezing mixture of ice and salt, for example, the evaporation of the water in the filled bulb, due to the cooling and condensation of vapor in the empty bulb, is so rapid as to carry off the heat to such an extent as to cause the water to freeze. Instead of employing the freezing mixture, a spray of ether or bisulphide of carbon may be projected upon the empty bulb with the same results.

This is a very interesting experiment, illustrating the principle of freezing by evaporation. It is the opposite of the popgun experiment illustrated and described in the last article on this subject. That was heat by compression. This is cold by rarefaction.

The candle bomb, shown in the annexed engraving, exhibits in a forcible way the explosive power of steam. It consists of a small bulb of glass filled with water and sealed. When held in a candle or lamp flame by means of a wire loop, it soon explodes violently.*

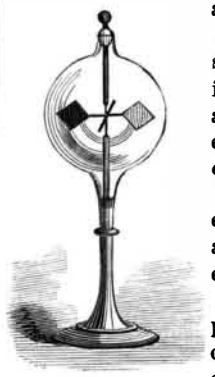


CANDLE BOMB.

The least expensive machine for applying to mechanical work the force exhibited by the candle bomb is the fifty cent engine, shown in the engraving below. It is a small and simple machine, but it is far more perfect than the steam engines of our forefathers. It will readily make 800 to 1,000 revolutions per minute. It is a wonderfully inexpensive example of the world's greatest motive power. Its construction is so well known as to require no description.

FIFTY CENT ENGINE.

The radiometer is one of those instruments which should perhaps be classed with scientific apparatus, but it may, nevertheless, be properly called a toy. It is a heat engine remarkable for its delicacy as well as its great simplicity. It illustrates a class of phenomena discovered by Crookes, which are complicated and difficult to explain in a brief and popular way.



RADIOMETER.

The instrument consists of a very slight spider of aluminum, supporting on the end of each of its four arms a very thin mica plate blackened on one side and silvered on the other side.

The aluminum spider is provided with a jewel, which rests upon a delicate needle point supported at the center of the glass globe.

The spider is retained on its pivot by a small tube extending downward from the top of the globe. When placed in sunlight or near a gas or lamp flame, the vanes revolve rapidly. Crookes' explanation of the radiometer is as follows: "The interior of the glass vessel being highly vacuous, the light or the total bundle of rays included in the term light, falling upon the blackened side of the vanes, becomes absorbed, and thereby raises the temperature of the black side. This causes extra excitement of the air molecules which come in contact with it, and pressure is produced, causing the fly of the radiometer to turn round." G. M. H.

Encouraging Inventors.

Until very recently the propriety of rewarding inventive genius, by securing to the originator of a public benefit certain rights, by which he might obtain remuneration for the labor and time expended by him in perfecting his invention, has not been questioned. A uniformly healthy sentiment has prevailed on this subject, which has materially assisted in increasing novelties of a useful character. The incentive of a pecuniary reward has stimulated the efforts of men of ability in every walk of life, and as a consequence there has been a marked improvement in the domestic economy of all civilized peoples.

The advantages of the patent right system are probably more apparent in the United States than in any other country. No nation has produced so many useful inventions as this, and to the efforts of American genius may be ascribed the complete revolution in several fields of labor which has rendered it possible for men who were once slaves of toil to work and at the same time enjoy life. This has a forcible illustration in the changed system of farming brought about by the patent agricultural implements now in general use. Before the introduction of these useful articles every grain of wheat was paid for, literally, by a drop of sweat; but now, although the farmer is still compelled to labor, he does it under such improved circumstances that it scarcely seems burdensome, and agriculture, as a consequence, has become a favorite pursuit, instead of being avoided, as it was at one period.

It would be idle to attribute the great strides made in mechanics to any other cause than the protection afforded to inventors by the patent laws. It is unfortunately true that the deserving originator is often deprived of his just rights by his inability to comply with the requirements of the law governing the granting of patents, or, as sometimes happens, through ignorance; but this does not affect the general result. It has been asserted, also, that irregularities occur in the issuance of patents by the commissioner, by which inventions are rejected as valueless on the ground that they do not possess sufficient novelty to entitle them to the protection of a patent, and subsequently another applicant is awarded letters for substantially the same thing originally declined. Such mistakes should not militate against the system.

The truth of the matter is, that the law in its present shape is a very good one, and it has the indorsement of all who are interested in the prosperity of the nation. That it may sometimes be abused is no argument against its advisability, for very few acts are absolutely perfect. So long as a reasonable protection is accorded to inventors, no one will have cause for fault-finding. Public opinion is strong enough, as was evinced recently in the sewing machine case, to restrain those having the power to give extensions from using their privilege when it is liable to work injury to the country at large. Those who have commenced a senseless opposition to the entire system because a few grasping men, following the natural instincts of human kind, have attempted to derive more benefit from it than they deserve, will see their error, and unite with us in expressing the belief that the encouragement of genius is the product of an advanced state of civilization, and for that reason merits the friendship of sensible men.—*The Manufacturers' Gazette.*

Snow Melting Apparatus.

A system of snow melting has been devised by Mr. F. Lyon, of 94 Harleyford Road, London. When it is considered that a fall of snow 6 inches deep, over one mile of road 60 feet wide, amounts to 5,866 cubic yards, the impossibility of removing it promptly by means of horses and carts is at once apparent—the more so when it is remembered that some metropolitan vestries have from 50 to 100 miles of road, and thus would have to deal with from 300,000 to 600,000 cubic yards of snow, assuming a 6 inch fall to occur. The principle of Mr. Lyon's invention is that the snow can be dealt with in the roads on which it falls when it is in a light and fleecy condition, and therefore easily melted. The apparatus consists of a wrought iron tube about 35 feet long, having a furnace at one end and a short length of vertical pipe for a chimney at the other. The tube is made in lengths of 6 feet, and each length is tapered so that they all fit into each other and are closely packed for transport on wheels. When a fall of snow occurs, the apparatus is to be laid along the gutters of the roads to be cleared, the width occupied being about 4 feet. A fire is then to be lighted in the furnace, the heat from which will pass along the horizontal tube, which has a flatly arched top. The snow is then to be shoveled on to the heated tube, which will melt it, the resulting water flowing away to the nearest gully. A trial of this apparatus took place in the St. Marylebone district in February, 1885, on some snow which had fallen long previously and had been twice carted. Notwithstanding the solidified condition of the snow and the imperfect condition of the experimental apparatus, it is stated that 21 yards of the consolidated snow, weighing 10 tons 8 cwt. 3 qrs., and equal to 198 yards of freshly fallen snow, were melted in 10 hours with a consumption of coke of the value of 1s. 7d., or under 1¾d. per ton.

Talcum Filter.

Talcum as a filtering medium, recommended by Dr. Fr. Hoffmann, is reported by the Committee on the National Formulary to be better, cheaper, and affording quicker filtration and clearer filtrates than other media previously used. Finely powdered white talcum should be well washed with hot water, slightly acidulated with hydrochloric acid, and again washed with pure hot water until no trace of acid can be detected. It is then dried, and may be used by adding the dry powder to the cloudy mixture, and filtering through paper; or the talcum filter may be constructed in the following manner:

Make a double filter out of white filtering paper, and insert it in a quart glass funnel; mix about half an ounce of talcum with one pint of hot water in a bottle and shake well, then pour it immediately upon the paper filter, taking care so to distribute the mixture that the entire filter from bottom to top is evenly covered with the fine powder. The water will be found to pass off rapidly and perfectly clear, after which the filter is ready for filtering any cloudy mixtures. The same filter may be used frequently for the same substances; but after it has been used the funnel should be covered with a glass plate, to exclude the dust and preserve the filter clean for the next operation.

* When experimenting with candle bombs, a guard of some sort should be provided, to prevent injury to the experimenter.