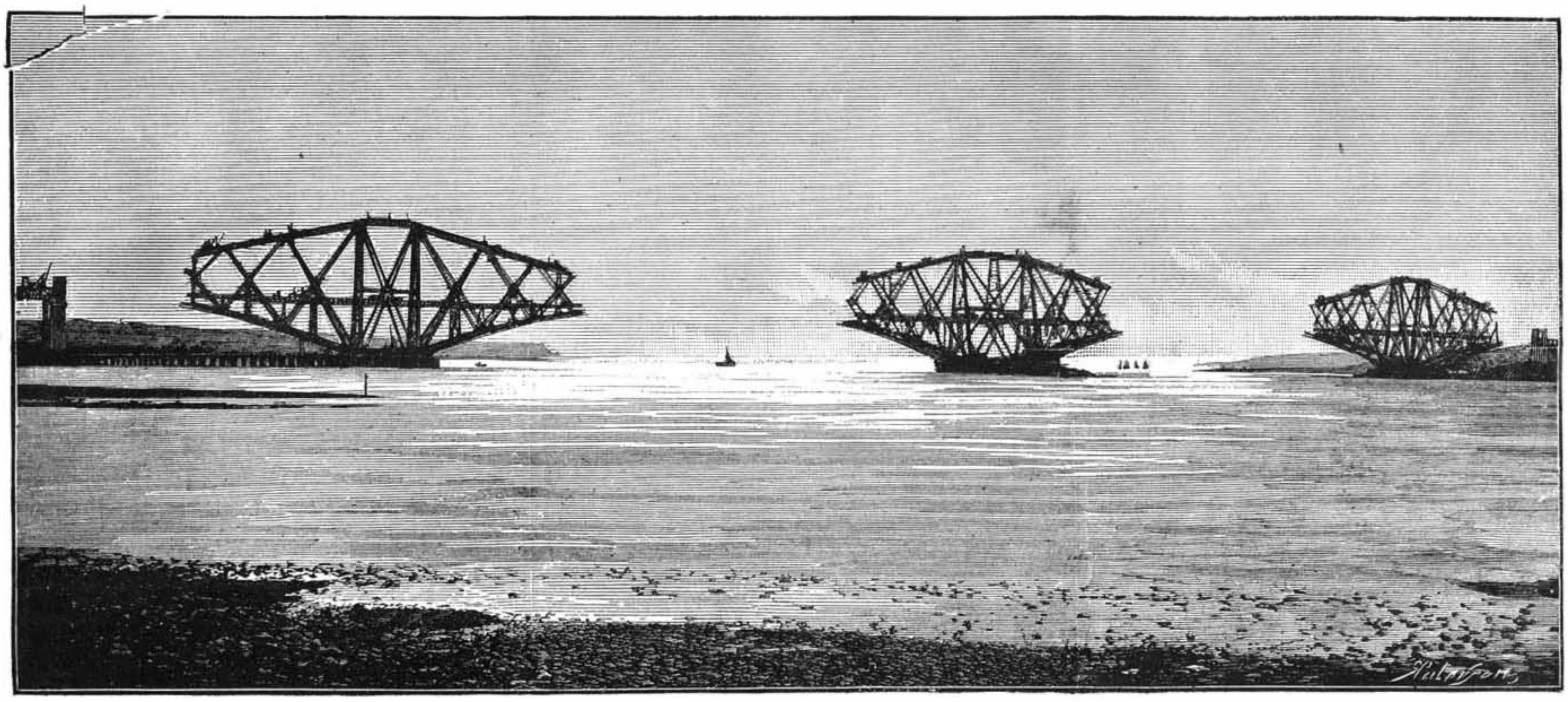
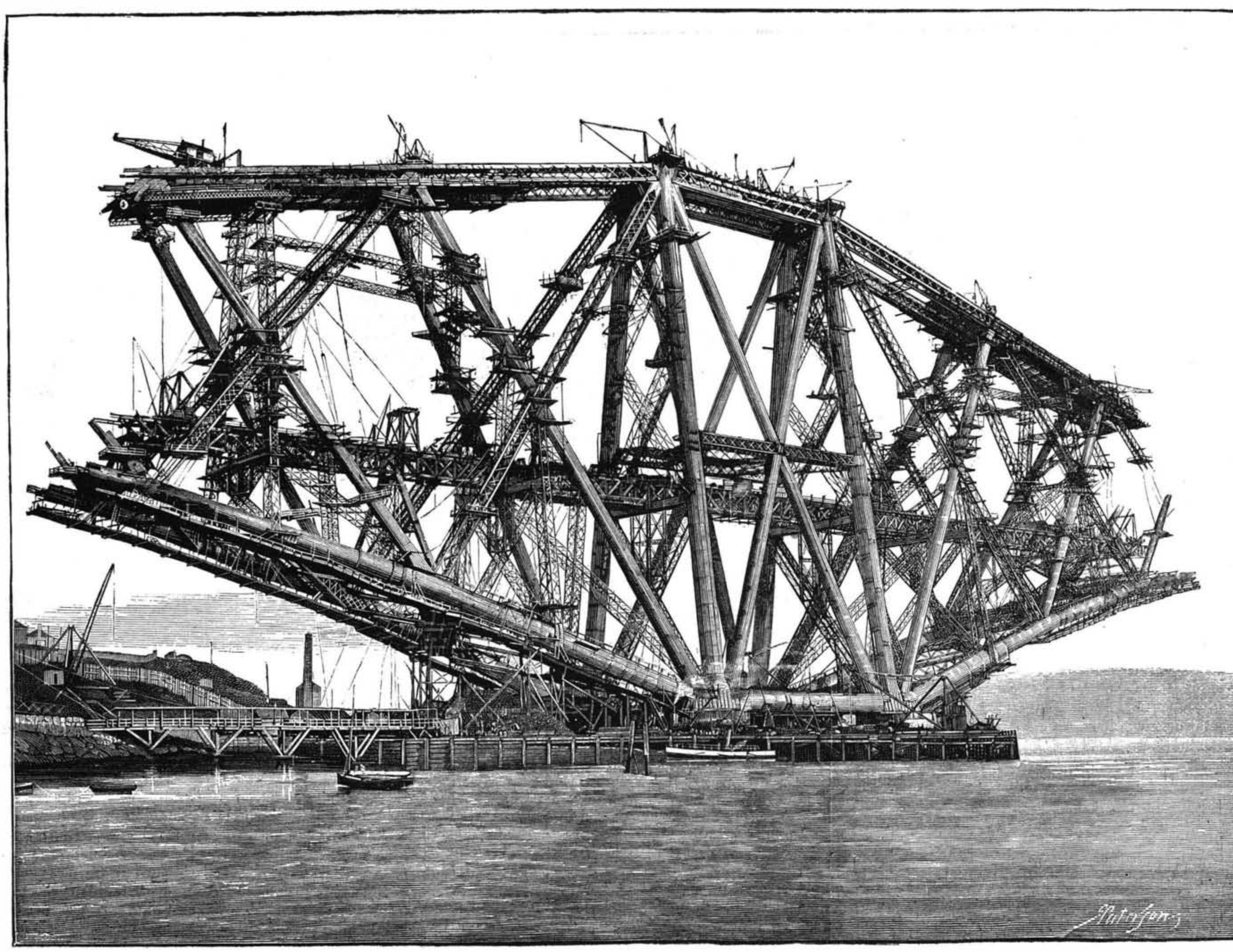
THE GREAT RAILWAY BRIDGE OVER THE FIRTH OF FORTH.

The construction of the great railway bridge to cross the Firth of Forth, at Queensferry, just beyond Dalmeny Park, where the opposite shores of Fifeshire and Linlithgowshire nearly approach each other, with the rocky islet of Inchgarvie between them, is one of the grandest works of modern engineering. It was designed, for the North British Railway Company, by Sir John Fowler and Mr. Benjamin Baker, has been four or five years in actual progress, and will be completed in the autumn of this year. The width of the estuary in this part is reduced by the peninsula of North Queensferry to a mile and a half, and on the south shore the water shoals rapidly, with a bed of bowlder clay and a very deep stratum of mud, but the Fife shore is an almost perpendicular cliff, and the intervening islet is a rock in the center of the deep channel, with 200 feet depth of water on each side, and with a strong tide current sweeping up and down on each side. It was impossible to erect piers anywhere but on this islet; hence the bridge must rest on three main piers, one at South Queensferry, one at Inchgarvie, and one on the Fife shore, besides two supplementary piers which serve to relieve the balance arms of the cantilever girders, and to connect the bridge with a long approach viaduct.

A cantilever is a girder supported at one point, its overhanging extended part being balanced by its weight at the other end. This engineering device is the most novel feature of the Forth Bridge. The main spans of the bridge are to be upheld over the deep water channels by the projecting ends of cantilever girders, with connecting central girders over about one-sixth of the span. Each cantilever girder is a complex structure framed of four vertical columns, standing not parallel, but from a wide base narrowing to the top; two bottom members, formed of horizontal tubes arranged in an upward curve of 680 feet span; two top members, consisting of box lattice girders arranged horizontally on vertical columns; twenty-eight struts, holding the top and the bottom together; and



VIEW OF THE BRIDGE FROM THE EAST.



FIFE MAIN PIER.

PROGRESS OF THE FORTH BRIDGE, QUEENSFERRY, NEAR EDINBURGH.

twenty-four ties, crossing and binding the struts, with secondary ties to assist in holding up the bottom, all made of steel. By these means, the Forth Bridge will be carried over two spans each of 1,710 feet (nearly a third of a mile), besides the half spans extending inland, where the ends of the cantilever girders, at and beyond the piers of support, are ballasted so as to counterbalance the weight of the suspended parts and of any trains passing over them. To allow for expansion or contraction of metal, the connecting central girders, resting on the cantilevers, each weighing about 800 tons, are only rigidly attached at one end, leaving the

POURING WATER INTO A SIEVE.

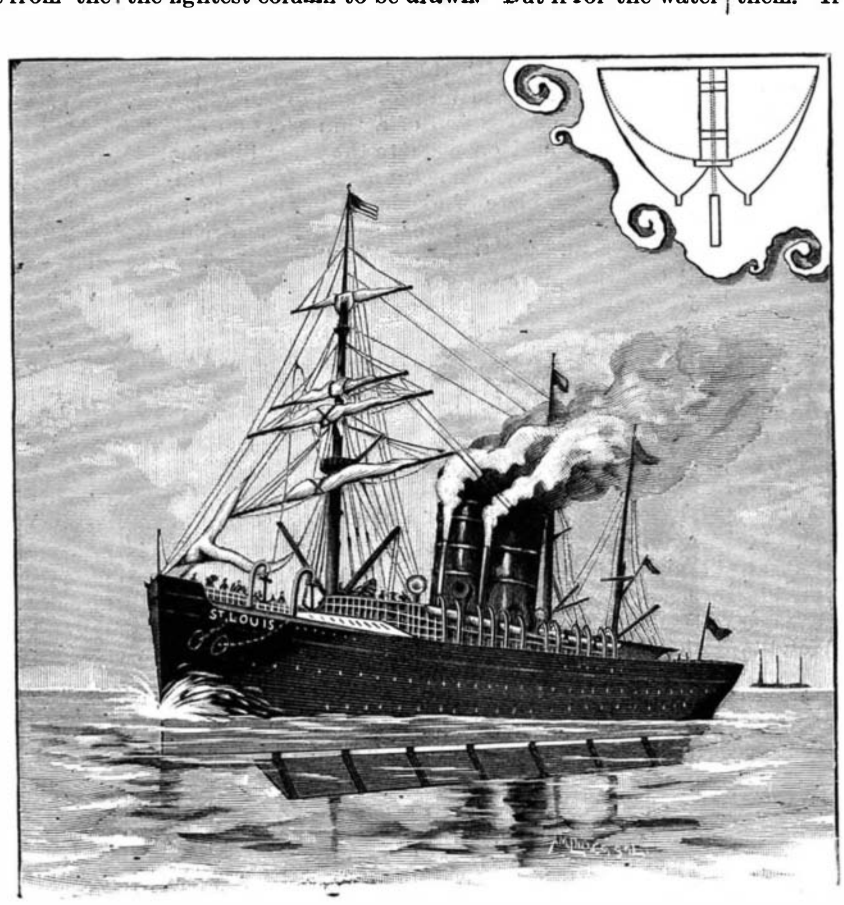
other end free. No one can fail to admire the mechanical ingenuity of the whole contrivance, which relies on the principle of "stable equilibrium," instead of a rigid union of all the parts of this immense and ponderous structure. It will scarcely, like the unfortunate Tay Bridge, be liable to be blown down by a gale of wind.

Our engravings show a general view of the Forth Bridge so far as it is at present completed, and a more detailed view of one of the piers and the great double cantilevers resting upon it.

We may repeat, in conclusion, that each opening of the Forth Bridge is one-third of a mile in clear span, which unprecedented width is spanned by a steel structure made up of two cantilevers or brackets, projecting 675 feet from the piers, and a central lever connecting the ends of the cantilevers. As shown in the engravings, the cantilevers project about 400 feet from the piers, and pieces are being added to the ends at a rate which will complete the bridge this year. It was reported that, during the recent storms which did so much damage to shipping, the Forth Bridge had suffered, but as a matter of fact not a plate or bolt was shaken, although, in its present condition, the structure has not one-half of its final strength.—*Illustrated London News.*

ST. LOUIS TO BE A SEAPORT.

A company has been formed in St. Louis, under the title of the Mississippi River and Ocean Navigation Company, with a capital stock of five millions of dollars, having for its object to establish direct ocean steamer lines between St. Louis, the West Indies, South America, etc., thus avoiding the great expenses of transferring and reshipping goods at New Orleans. A large amount of valuable information and cogent reasons in favor of this new enterprise are given in a pamphlet issued by the company. The prospective trade to be commanded by such lines of vessels is set forth as very great and very profitable. In order to realize the project in a practical manner, the company proposes to build its steamers on the plans invented by Andrew H. Lucas and John F. Cahill, of which we herewith present an illustration. The ships are to have double hulls and dropkeels, so they may readily navigate shallow waters.



IMPROVED DOUBLE-HULLED AND DROP-KEELED STEAMSHIPS.

The cut shows the manner of application of the adjustable or drop keel. When in actual use, however, the cylinders are not to be exposed, as shown in the illustration, as the strain would be too severe on the uprights by means of which the drop keel is suspended and made to ascend or descend between the two hulls, as shown in Fig. 2. When in use, the upper part of the drop keel is held firmly in place by stout steel braces constructed along the entire length of the inner sides of the two hulls.

The mechanism for raising and lowering it will be mounted in connection with the engine shaft of the vessel. It will be understood that the series of pinions or screws for manipulating the drop keel are to be run together and at the same rate of speed, so that there will be no straining or cramping of the parts in the cylinders. The movable keel may be lowered at will any distance equal to the loaded immersion of the ship. From the bow to a point over the forward end of the drop keel the ship is to be built solid, with watertight compartments. Her engines are to be of the triple expansion type, and her motive power the twin screw. The inventor has devised an original system of propulsion, by means of which every pound of steam power may be utilized and a higher rate of speed reached than is attained by any of the marine engines now in use. If this system should be found practicable, an extraordinary rate of speed is certain, as the construction of the ship affords excellent facilities for the use of auxiliary twin screws placed near the stern of each of the hulls. The loaded draught of a vessel of 1,000 tons will not exceed seven feet. The additional immersion of the drop keel will give the ship all the strength and stability requisite for safety in stormy weather and high rolling seas. The cylinders pass upward through the decks and are securely fastened between steel bridges equally distributed along three-fourths of the ship's length, thus relieving the immersed movable keel of all undue strain.

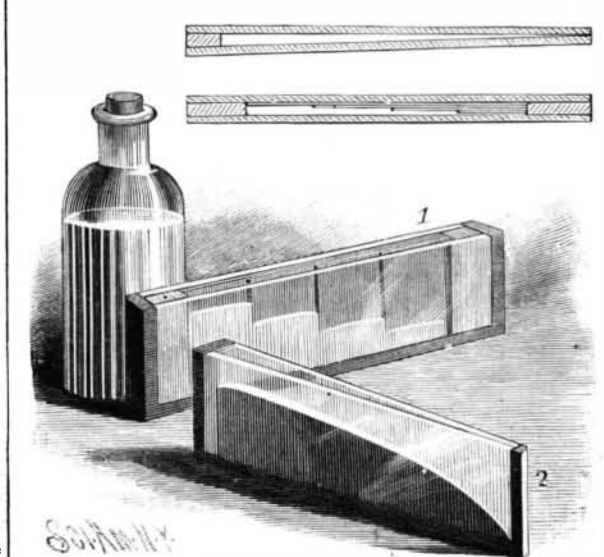
Each of the hulls is, likewise, provided with its own keel, so as to facilitate navigation.

EXPERIMENTS IN CAPILLARY FORCE.

What may be termed the reaction of capillarity as manifested between solids and liquids is divisible into two classes. One of these is illustrated in the case of a liquid wetting a solid, typical examples of which are found in blotting paper, in the drying action of a towel, and in many experiments founded on this general basis. Where the liquid wets the solid, the forces of adhesion and cohesion are both developed, and a distinct type of phenomena comes into play. But where the liquid does not wet the solid, as in the case of mercury against wood or glass, an action dependent on cohesion alone, or very slightly modified by adhesion, is produced. In the illustrations accompanying this article several illustrations of what may be termed the capillarity of cohesion are shown.

It is a well known fact that if water is poured between two plates of glass held a slight distance apart, but nearer at one end than at the other, the fluid will rise the highest between the plates where they are the closest. The liquid will thus form a curve, in general sense a hyperbola concave upward. The water is attached to the glass by adhesion, travels upward, and by cohesion draws the liquid column after it, naturally to the greatest height, where there is the least liquid or the lightest column to be drawn. But if for the water we substitute mercury—a fluid which does not wet glass—the force of adhesion does not appear, cohesion draws the mercury strongly together and pulls it down to the greatest distance, where there is the least mercury to be acted on. This place is, of course, where the glass is closest, so that if mercury is poured between two plates of glass nearer at one end than at the other, it will rise to the greatest distance where the plates are farthest apart, and will descend in a curve convex upward. This curve will be directed toward the part of the glass plates which are nearest together. It is the reverse of the water curve.

In Fig. 2 of the drawings is shown such a trough, containing mercury. The upper sectional figure shows its construction. It is made of two pieces of glass cemented together by means of a little sealing wax, two of their edges being in contact, and two held apart by a slip of glass or cardboard. A piece of paper may be cemented over the bottom with gum tragacanth as a cementing material, or the opening may be closed with sealing wax or otherwise, as desired. This forms a wedge-shaped trough. When mercury is poured into such a receptacle, it takes a very peculiar shape, shown in Fig. 2. In Fig. 1 of the same illustration a varia-



MERCURY TROUGHS.

tion on this is shown. Here the tank is constructed of plates of glass parallel one to the other; but before being put together, a series of strips of paper are pasted on one of them, each slip being about one-fourth of an inch or more shorter than the one beneath it. In this way the open space is divided into a series of step-like divisions of varying width, each division, however, having practically parallel sides. If mercury is poured into this trough, it will arrange itself into a series of steps, as shown in Fig. 1.

In the next illustration, the same idea is carried out and applied to water. A cup is made of No. 50 gauze. The seams are joined by soldering, and the bottom has its edges bent upward, and is also soldered in place. It is then heated, when perfectly dry, and thoroughly coated with paraffine. This fills the meshes. When sufficiently coated, it is again heated, and the paraffine is expelled from the meshes by sharply blowing against them. If now the cup is held as shown and water is poured into it very gently and along one of its sides, there is no difficulty in filling it to the depth of three inches or more with water. This illustrates water held in a sieve. If a finger of the hand holding the cup is wet, the water as it rises to the level of the moistened part will at once rush out. If, when the cup is full, the wet finger is rubbed on the bottom, this will be sufficient to cause the water to escape. The cup will float upon water for an indefinite period, but if inverted and placed like a diving bell, will at once sink.

The water in this experiment practically forms a film or membrane, not touching the wire gazue and holding the body of the water together. The figure on the upper part of the cup is an attempt to show how the water rests upon the wires. The little film is bowed down between every two wires, forming a species of sac.

The experimenter must remember to have his hand perfectly dry. It is very curious, as the water rises, to feel its chilling effect through the wire gauze without the hand being at all moistened.

Crowley's Brain.

Crowley was a chimpanzee. He was an interesting feature at our zoological museum, and his human traits offered much amusement to visitors. Crowley's portrait, and a description of his antics, was published in the SCIENTIFIC AMERICAN of October 23, 1886. He died a few months ago, and his brain has been examined by Dr. Spitzka, who finds that it weighs less than one-third that of a human brain, but in the course of the examination he made an important discovery. At the floor of the fourth ventricle in intelligent persons there are what are called auditory streaks, which are supposed to have something to do with hearing and the power to distinguish the different words of a language, and in the brain of this chimpanzee were found faint white streaks in this area—a fact more remarkable when it is borne in mind that in deaf mutes these auditory streaks are not to be found.