Light, (assuming its materiality,) is attracted by the particles and masses of other matter; and if this attraction be equal, or nearly so, on all sides, it will pass through the body upon which it falls; and that body will be called transparent: if, on the other hand, it be attracted unequally by the particles of the body, it will obey the strongest force, and its course will be changed; and if this be frequently repeated, it will not pass through, and the body will be opaque. Through a single piece of glass, the light will therefore pass readily, it being attracted equally in all directions, the density of the mass, being equal; but if we reduce this mass to powder, although each individual particle will still be transparent, the accumulated particles will not be so; the light, in passing near their angles, will be inflected; and in striking upon their sides, will be refracted; and being thus repeatedly turned out of its course, will not pass through. If we could now find a fluid of the same density with the glass, or rather one which possessed an equal attraction for the particles of light, and were to pour this upon the powdered glass, we should fill up all the interstices, and in effect, annihilate the angles and surfaces of the particles; the light would again be equally attracted on all sides, and would pass on its course. The effect would be the same as that of pouring in melted glass; or, as remelting the particles, and reducing them again to a single mass. Paper consists of particles entangled and agglutinated together, with numerous refracting and inflecting surfaces; if between them, we can insinuate an article, equal in its refracting power to the particles of the paper, it will become transparent; if we approach it only, semi-transparency will be produced, which is all we usually attain.

FOR THE FRANKLIN JOURNAL.

ON SPECIFIC GRAVITY.—No. I.*

By ROBERT HARE, M. D. *Professor of Chymistry in the University of Pennsylvania.*

A clear conception of Specific Gravity, is necessary, to a comprehension of the language of the most useful sciences and arts. It may be defined, the ratio of the weight of a body, to its bulk.

On the means of ascertaining Specific Gravities.

The object of all the processes for this purpose, is, either to ascertain the weight of known bulk, or the bulk of known weight. When masses are reduced to the same bulk, it is only necessary to weigh them. When they are reduced to the same weight, it is only

* It is not proposed in the former part of this article, to offer any thing new, upon the subject of Specific Gravity; it is only given as introductory to the description and use of some instruments, which, it is believed, will be found in many instances, more convenient in their application, than any which have been hitherto employed.

necessary to measure them. If water were among a number of substances reduced to the same bulk, and weighed, and its weight assumed as a unit, the numbers found, would be the same as those now in use to express specific gravities. The gravity of water has been assumed as the standard, because this fluid may almost always be had, sufficiently pure; and it is generally easy to ascertain the weight of a quantity of it, equal, in bulk, to any other body.

In order to obtain the specific gravity of a body, therefore, we have only to divide its weight, by the weight of a quantity of water equal to it in bulk.

The weight of a quantity of water, equal to the body in bulk, is equal to the resistance which the body encounters in sinking in water. Hence, if we can ascertain, in weight, what is necessary to overcome the resistance which a body encounters in sinking in water, and divide, by this weight, thus ascertained, the weight of the body, we shall have its specific gravity.

In the case of a body which will sink of itself, the resistance to its sinking, is what it loses of its weight, when weighed in water.

In the case of a body which will not sink of itself, the resistance to its sinking, is its weight added to the weight which must be used to make it sink.

Experimental Demonstration, that the resistance which a body encounters, in sinking into any fluid, is just equivalent to the weight of a portion of the fluid, equalling the body in bulk.

This proposition may be experimentally demonstrated, by means of the apparatus, represented by the following figure.

The cylinder, represented as surrounded by the water of the vase, (V) is made to fit the cavity of the cylinder suspended over it so exactly, as that it enters the cylinder with difficulty, on account of the included air, which can only be made to pass by it slowly. It must, therefore, be evident, that the cavity of the hollow cylinder, is just equal in bulk to the solid cylinder, which so exactly fits it.

Both cylinders, (suspended as seen in the plate) being counterpoised accurately upon a scale beam; let a vessel of water be placed in the situation of the vase, in the drawing. It must be evident, that the equiponderancy must be destroyed, since the solid cylinder will be buoyed up by the water. If water be now poured into the hollow cylinder, it will be found, that, at the same moment when the cavity becomes full, the equiponderancy is restored, and the solid cylinder sunk just below the surface of the water.

It therefore appears, that the resistance which the solid cylinder encounters, in sinking in the water, is overcome by the weight of a quantity of the water equal to it in bulk. It must be evident, that the same would be true of any other body, and of any other fluid.

Rationale.

When a solid body is introduced into an inelastic solid, on withdrawing it, a hole is left, which remains vacant of the solid matter: but, no sooner is a body, which has been introduced into a liquid, withdrawn, than the liquid is found to fill up the space from which it has been removed.

It is evident, that the force which liquids exert, thus to re-enter any space within them, from which they are forcibly displaced, is precisely equal to the weight of a quantity of the liquid, commensurate with that space; since, when the space is re-occupied by the liquid, the equilibrium is restored. Consequently, every body, introduced into a liquid, experiences from it a resistance equal to the weight of a quantity of the liquid, commensurate with the cavity, which would be produced, supposing the liquid, frozen about the solid mass, split open so as to remove it, and the fragments put together again: and the cavity also thus created, must obviously be exactly equal to the bulk of the body. It follows, that the resistance which any body encounters in sinking, within a fluid, is equivalent to the weight of a quantity of the fluid, in bulk equal to the body.

To ascertain the Specific Gravity of a Body heavier than Water.

Let the body be the glass stopple, represented in the succeeding figure.

First counterpoise the stopple by means of a scale beam and weights, suspending it by a fine metallic wire. Place under the stopple, a vessel of pure water, and lower the beam, so that, if the stopple were not resisted by the water, it would be immersed in that fluid. Add just as much weight, as will counteract the resistance which the water opposes to the immersion of the stopple, and renders the beam again horizontal. Divide the weight, by which the stopple had been previously counterpoised, by the weight thus employed to sink it. The quotient will be the specific gravity.

Rationale.

The weight required to sink the stopple, is equal in weight to the bulk of water which the stopple displaces. Of course, pursuant to the general rule, it is only necessary to see how often this weight is contained in the weight of the stopple, to ascertain the specific gravity.

To ascertain the Specific Gravity of a Body lighter than water.

Let a small glass funnel be suspended from a scale beam, and counterpoised so as to be just below the surface of some water in a vase, as in this diagram.

If, while thus situated, a body lighter than water, a small cork for instance, be thrown up under the funnel, the equilibrium will be subverted. Ascertain how much weight will counteract the buoyancy of the cork, add this to its weight and divide its weight by the sum—the quotient is the answer.

Rationale.

The force with which the cork rises against the funnel, is equal to the difference between its weight and the weight of the bulk of water which it displaces. Of course, ascertaining the force with which it rises, by using just weight enough to counteract it, and adding this weight, so ascertained, to that of the cork, we have the weight of a bulk of water, equal to the bulk of the cork. By this, dividing the weight of the cork, agreeably to the general rule, the specific gravity of the cork will be found.

To ascertain the Specific Gravity of a Liquid.

Let the stopple be counterpoised, exactly as in the last experiment, only that it is unnecessary to take any account of the counterpoising weight.

Having, in like manner, ascertained how much weight will sink it in the liquid, divide this by the weight required to sink it in water, as above. The quotient will be the specific gravity sought.

Rationale.

It has been proven, that the resistance to the sinking of a body in any fluid, is precisely equal to the weight of a bulk of the fluid, equal to the bulk of the body. Ascertain the resistance to the immersion of the same body in different fluids, is, therefore, the same as ascertaining the weights of bulks of those fluids, equal to the body, and, of course, to each other. And if one of the liquids be water, the weight of this, divided by the weight of the others, gives their specific gravities.

If the stopple be so proportioned, as to lose just one thousand grains, by immersion in water, division is unnecessary, as the weight of the liquid will be obtained in grains, which are thousandths by the premises. A metallic mass, of the same weight as the stopple exactly, may be employed as its counterpoise.

In these experiments, the liquid should be as near 60° of Fahrenheit's Thermometer as possible.

On the application of the sliding rod measurement, in Hydrometry.

There is, in my opinion, no mode of measuring fluids, heretofore contrived, so accurate and convenient, as that which I have employed in my Eudiometers. I allude to the contrivance of a rod,

or piston, sliding through a collar of leathers into a tube, and expelling from it any contained fluid, in quantities measured by degrees marked upon the rod; and perused, with additional accuracy, by means of a vernier.

One of the most advantageous applications of the mechanism alluded to, is, in ascertaining specific gravities, in the case either of liquids or solids. To assay liquids which are not corrosive, I have employed two instruments like that represented in the following figure, severally graduated to 100 degrees, and furnished with a vernier, by which those degrees may be divided into tenths, and each scale made equivalent to 1000 parts.

In order to avoid circumlocution, I shall, to the instrument here represented, give the name of *Chyometer*; from the Greek, *chuo*, to pour, and *meter*, measure.

Supposing two such instruments to be filled, to the extent of the graduation, one with pure water, the other with any spirituous liquid, lighter than water, whose gravity is to be found; let 1000 parts of the liquid be excluded into one scale of a beam, and then exclude into the other scale as much water as will balance it. Inspecting the graduation of the *Chyometer*, from which the water has been expelled, the numbers observed, will be the answer sought. For, supposing 1000 measures of alcohol were placed in one scale, if 800 measures of water counterbalance it, the alcohol must be to the water, in weight, as 800 to 1000; which is all that is requisite to be known: since it is self-evident, that when any two masses are made equal in weight, their gravities must be inversely as their bulks.

To ascertain the specific gravity of a solid, by the Chyometer.

For this purpose, the body, whose gravity is in question, should be suspended in the usual way, beneath one of the scales of a balance, and its weight, in parts of water, at 60° F. ascertained, by measuring from the *Chyometer*, into the opposite scale, as many parts as will balance the body. Being thus equipoised, and a vessel of pure water, at the same temperature as that introduced by

the Chyometer, duly placed under it; the number of parts of water, competent exactly to cause it to be merged in this fluid, will be the weight of a quantity of water, equivalent in bulk to the body. Of course, dividing, by the number thus observed, the weight of the body, in parts of water as previously found, the quotient will be the specific gravity sought.

This process ought to be easily understood, since it differs from the usual process only, in using measures of water, instead of the brass weights, ordinarily employed.

The Chyometer enables us to make new weights, out of water, for each process.

To ascertain the specific gravity of a corrosive fluid, by the Chyometer.

The process, described in the preceding page, is only applicable, where the fluid is not of a nature to act upon the sliding rod. By employing a body—a glass bulb for instance—appended from a balance, as in the usual process, we may use water, measured by the Chyometer, in lieu of weights.

First, having counterbalanced the body exactly, ascertain how many parts of water will cause it to sink in water; next, how many parts will cause it to sink in the liquid, whose gravity is to be ascertained. The number last found, being divided by the first, the quotient is the specific gravity sought.

Supposing that the graduation be made to correspond with the size of the bulb, so that 1000 parts of pure water will just sink the bulb in another portion of the same fluid; the process for any other liquid, will be, simply to ascertain how many parts of water will sink the globe in it. The number observed, will be the specific gravity; so that recourse to water, or to calculation, would be unnecessary.

The rationale of this last mentioned process, is given, in the case of ascertaining the gravity of liquids, by the glass stopple, weighing 1000 grains.—(See page 45.)

[TO BE CONTINUED.]

IRON AND STEEL.

The Technical Repository contains a series of valuable papers, written by the Editor of that Journal, on the subject of iron and steel. These it is intended to republish, with such remarks and observations, as may be deemed useful to the operative mechanic. All the arts of civilized life depend, immediately, or remotely, upon the use of iron; and numerous have been the improvements made within a very few years, particularly in England, in the casting, and in the conversion of cast, into malleable iron, and of the latter, into steel; as also in improving their qualities, in a degree which, a few years since, would have been thought impracticable.