wards the foot. Dies thus hardened, preserve their forms until they are fairly worn out.

I am aware that the above mode is now in frequent use, as Mr. Eckfeldt never wished to keep it secret; a gentleman of the mint, communicated the process to a friend in Birmingham, England, where, it is believed, it was not previously known.

Should you think the above information worth publishing, you will probably receive some other communications, containing improvements effected by the same gentleman.

Yours very respectfully,

K.

ON SPECIFIC GRAVITY.—No. II.

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

To find the specific gravity of a Mineral, without calculation, and without degrees.

Fig. 5.

The preceding figure represents a balance employed in this process. It is, in two respects, more convenient than a common balance. The moveable weight on one of the arms, renders it easier to counterpoise bodies of various weights; and, the adjustment of the index (I) by the screw (S) to the beam, saves the necessity of adjusting the beam to the index; the accurate accomplishment of which, by varying the weights, is usually a chief part of the trouble of weighing.

One of the buckets, suspended from the beam, is five times as far from the fulcrum as the other.

A chymeter is employed in this process, of which the following figure will convey a correct idea.

The rod of this instrument is not graduated, but is provided with a band, (B) which can be slipped along the rod, and fastened at any part of it by means of a screw.

Let a mineral be suspended from the outer bucket, and rendered equiponderant with the counter-weight, (W) by moving this further from, or nearer to the fulcrum, so that the index point (I) may be exactly opposite the point of the beam. Place under the mineral a vessel of water, and add as much of this fluid to the bucket, by means of the chymeter, as will cause the immersion of the mineral. The band (B) which is made to slip upon the rod, should be so fastened, by means of the screw, as to mark the distance which the rod has entered, in expelling the water, requisite to sink the mineral. Having removed the vessel of water, and the mineral, ascertain how many times the same quantity of water, which caused the immersion of the mineral, must be employed to compensate its removal.

Adding to the number, thus found, one, for the water, (previously introduced into the bucket, in order to cause the immersion of the mineral) we have its specific gravity; so far as it may be expressed without fractions. When requisite, these may be discovered by means of the second bucket, which gives fifths for each measure of water; which, if added to the outer bucket, would be equivalent to a whole number. By the eye, the distance is easily so divided, as to give half fifths, or tenths. Or, the nearest bucket, being hung one half nearer the fulcrum, the same measures will become tenths in the latter, which would be units, if added to the outer bucket.

Rationale.

The portion of the rod, marked off by the band, was evidently found competent, by its introduction into the tube of the chymeter, to exclude from the orifice a weight of water, adequate to counteract the resistance encountered by the mineral in sinking in wa-

ter: consequently, agreeably to the general rule,* to find the specific gravity of the mineral, we have only to find how often this weight (of water) will go into the weight of the mineral—or, what is the same in effect, how often the former must be taken, in order to balance the latter. Indeed it must, otherwise, be sufficiently evident, that the mineral and the water being made equal in weight, their specific gravities must be inversely as their bulks, which are known by the premises.

The inner bucket may be dispensed with, and greater fractional accuracy attained, by means of a sector, graduated into 100 parts. It is for this purpose that the sliding band, and the ferrule at the but-end of the tube, are severally furnished with the points. The assistance of a sector is especially applicable, where fluids are in question, since it is necessary to find their differences in thousandth parts.

To find the specific gravity of a liquid, by the Sectoral Chyometer.

Let a glass bulb, (represented in figure 5, under the buckets,) be suspended from the outer bucket, and counterpoised. Let the situation of the beam be marked, by bringing the point of the index opposite to it. Let the tube of the chyometer be full of water, and the rod retracted, until stopped by an enlargement purposely made at its inner termination. Next return it into the tube, until as much water is projected into the bucket, as is just adequate to cause the immersion of the bulb. Let the band be fastened upon the rod, close to where it enters the tube, so as to mark the extent to which it may have entered. The rod must in the next place, be drawn out from its tube, to its first position; and the sector so opened, as that the points may extend from 100 degrees on one leg to 100 upon the other. Leaving the sector thus prepared, place under the suspended ball, a vessel containing an adequate quantity of the fluid, whose gravity is required. If the fluid be lighter than water, in order to cause the immersion of the bulb in it, the rod will not have to enter so far, as at first. This distance being marked, by fixing the sliding cylinder, and the rod withdrawn from the tube as far as allowed by the stop, the number on each leg of the sector, with which the points will coincide, gives the gravity of the fluid. Forcing as much water into the bucket as had been sufficient to sink the bulb in water, will not sink it in a heavier liquid; consequently, in the case of such liquids, it will be necessary to fill the chyometer a second time, and force as much more water from it, as may be sufficient to cause the immersion of the bulb. The sliding band being then fixed, and the points separated and applied to the sector, as before, the number to which they extend must be added to the weight of water = 100, for the specific gravity of the fluid in question.

Small differences are better found by subtraction; as, for instance, suppose the specific gravity of the fluid were 101; after the small

* See No. 1, page 44.

addition of water made to the bucket, beyond the 100 parts required for the immersion of the bulb *in water*, (the band being unmoved), the points would extend from 99 on one leg, to 99 on the other. The difference between this number, and 100, is then to be added to the weight of water; so that the specific gravity is found to be 101.

The angle made by the sectoral lines in using the same bulb, and the same rod, will always be the same. Hence, a stay may be employed to give the sector the requisite opening.

Indeed, were liquids alone in question, an immoveable sectoral scale would answer. Thus prepared, it were unnecessary to have recourse to water, excepting in the first adjustment of the scale. The number of parts required to merge the bulb in any fluid, will reach (at once or twice) the number, or numbers, on the sector, which give the required gravity.

In this process, if greater accuracy be desirable, it is only necessary to employ a smaller rod or a larger bulb. Instead of effecting an immersion by one stroke of the rod, it may be done by ten strokes, which will make each division of the sector indicate a thousandth of the bulk of the bulb.

The following process is, however, preferable, as the sector is made to give the answer in thousandths, without the delay of filling and emptying the chymometer more than once.

Let the distance on the rod of the chymometer be ascertained; which, when introduced five times successively, will exclude just water enough to overcome the resistance encountered by a globe, in sinking in that fluid. Let the sector be opened, to the distance so designated: let the globe be partially counterpoised, so as to float in any liquid heavier than 800. The apparatus being thus prepared, if the globe be placed in a liquid, in which it floats, add as much water, from the chymometer, to the scale, from which it hangs, as will sink it—and, by means of the points and the sector, ascertain the value of the distance to which the rod has been introduced. Adding the numbers, thus found, to 800, the sum will be the specific gravity of the liquid.

For this process, the sector should be divided into 200 parts, and, the proper opening being once duly ascertained, should be preserved by means of an arc, like that attached to common beam compasses.

Instead of a globe, a hydrometer, surmounted with a cup, may be employed, either with a graduated, or a sectoral, chymometer.

Before taking leave of the reader, it may be proper to explain the use of the square dish, which may be seen to the left, under the beam, (figure 5.) The arc of wire is for the purpose of suspending the dish to the hook, in place of the outer bucket. When so suspended, filled with water, and duly balanced, it will be found soon to become sensibly lighter, in consequence of the evaporation of the water. By means of the chymometer, it is easy to ascertain the different quantities evaporated, in similar times, at different periods, and in different places; so that, guarding against the effect

of aerial currents, hydrometrical observations may be made with great accuracy.

In lieu of having points attached to the chymometer, as represented in the figure, it may be as convenient to have two small holes, for the insertion of the points of a pair of compasses, either of the common kind, of the construction used by clock makers, or that which is known under the name of beam compasses.

The compasses may be used to regulate the opening of the sector, or to ascertain, by the aid of that instrument, the comparative value of the distances which the rod of the chymometer has to be introduced into its tube.

In order to convey an idea of the nature of the sector to any reader who may be unacquainted with it, I trust it will be sufficient to point out, that its construction is similar to that of the foot-rule used by carpenters. We have only to suppose such a rule, covered with brass, and each leg graduated into 200 equal parts, in order to have an adequate conception of the instrument employed by me.

A more particular explanation of the principle of the sector, may be found in any Encyclopedia, or Dictionary of Mathematics.

WATER WHEELS.

On the construction of water wheels and the method of applying the water for propelling them so as to produce the greatest effect.

To the Committee of the Franklin Institute in Philadelphia.

In constructing water-wheels, especially those of great power, the introduction of iron is a most essential improvement, and if this metal, and artisans skilled in the working it, could be obtained at reasonable rates, water wheels might be made wholly of it, and prove ultimately the cheapest, as if managed with due care, and worked with pure (not salt) water, they would last for centuries; but as the first cost would be an objection, I would recommend in all very large wheels that the axis be made of cast iron, and in order to obtain the greatest strength with the least weight, the axis or shaft ought to be cast hollow, and in the hexagon or octagon form, with a strong iron flange to fix each set of arms and the cog wheel upon; these flanges to be firmly fixed in their places with steel keys.

On the adaptation of water wheels to the different heights of the water falls by which they are to be worked, I remark that falls of 2 to 9 feet are most advantageously worked with the undershot wheel; falls of 10 feet and upwards by the bucket or breast wheel, which up to 20 or 25 feet ought to be made about one-sixth higher than the fall of water by which it has to be worked; and in wheels of both descriptions, the water ought to flow on the wheel from the