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**XLI. On the Application of the Sliding Rod Measurement in Hydrometry.** By ROBERT HARE, M.D. Professor of Chemistry in the University of Pennsylvania\*.

**T**HERE 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 ascertained, 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

\* Communicated by the Author.

water counterbalance it, the alcohol must be to the water in gravity as 800 to 1000; 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° Fahr. 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.

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.*

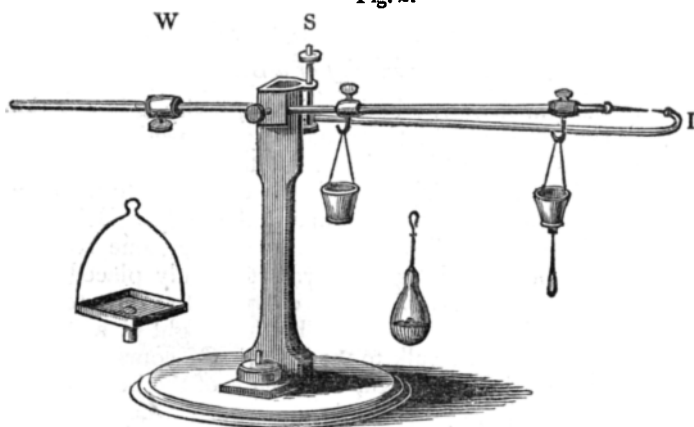
The process described in the preceding page, is only applicable where the fluid is not of a nature to act upon the sliding rod. By employing a body,—a glass bulb for instance,—appended from a balance, as in the usual process, we may use water measured by the chyometer, in lieu of weights.

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.

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 bulb in it. The number observed, will be the specific gravity; so that recourse to water, or to calculation, would be unnecessary.

*To find the Specific Gravity of a Mineral, without Calculation, and without Degrees.*

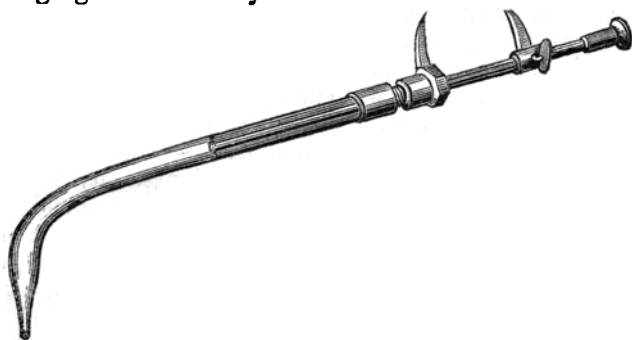
Fig. 2.



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



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

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 chymometer, 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 chymometer, to exclude from the orifice a weight of water, adequate to counteract the resistance encountered by the mineral in sinking in water: consequently, 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 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 ferule 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 thousandths.

*To find the Specific Gravity of a Liquid, by the Sectoral Chyometer.*

Let a glass bulb (represented in fig. 2, 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 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

toral 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 chyometer more than once.

Let the distance on the rod of the chyometer 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 chyometer 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 chyometer.

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 (fig. 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 chyometer, 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 chyometer, as represented in the figure, it may be as convenient to have two small

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 Encyclopædia, or Dictionary of Mathematics.

**XLII.** *On the Skeleton of the Plesiosaurus Dolichodeirus discovered in the Lias at Lyme, in Dorsetshire, in the Collection of His Grace the Duke of Buckingham.*

**THE** plate (III.) given in our present Number, represents a nearly perfect skeleton of the *Plesiosaurus Dolichodeirus*, described by the Rev. W. D. Conybeare, F.R.S. &c. in a memoir given at p. 412 of our 65th volume. The drawing from which the original plate in the Geological Transactions was engraved was executed with extreme care by Mr. Webster. The several parts are described in the memoir.

“The bones are entirely imbedded in a matrix of lias shale, which, though intersected in several places by lines of fracture, has evidently, from the mutual adaptation of the parts, formed one entire mass. Above twenty of the cervical vertebræ connected with the head, lie together unbroken.

“We have omitted to state in the memoir, that a second unbroken specimen of the entire vertebral column, from the head to the tail, was found at the same time and place with the one here represented; and has been presented by Professor Buckland to the museum at Oxford.”—*Trans. Geol. Soc. Sec. Ser. vol. i.*

[See a delineation of the Skeleton conjecturally restored in Plate III. vol. lxv.]