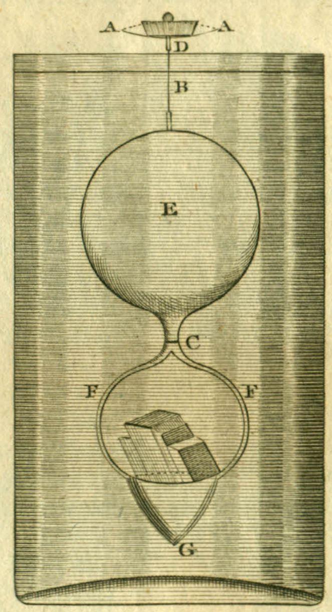

A

DESCRIPTION

OF A

NEW INSTRUMENT

FOR MEASURING THE

SPECIFIC GRAVITY OF BODIES.

BY WILLIAM NICHOLSON,

IN A LETTER TO MR. MAGELLAN.

WARRINGTON:

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A DESCRIPTION OF A

NEW INSTRUMENT

FOR MEASURING THE

SPECIFIC GRAVITY OF BODIES.

DEAR SIR,

ACCORDING to my promise, I transmit to you an account of the Instrument I have constructed for the easy and exact finding the specific gravities of bodies. It appears to me to be as perfect, as the nature of a floating instrument of this kind will admit of; and, for that reason, I presume it will not be impertinent to mention previously what has been done in this way.

It seems to follow from a passage in Boyle's account of a new Essay Instrument, * that the

* Lowthorp's abridgment of the Philosophical Transactions, vol. I. p. 604. Or Boyle's Works in 4to. edit. London, 1772, vol. IV. p. 204.

 Hydrometer,

Hydrometer, or Areometer was first invented by that great philosopher. The essay instrument here mentioned, was intented for the hydrostatical proof of metals, and was adapted to serve chiefly for guineas. It consisted of a ball, somewhat less than an hen's egg, with a stem of four or five inches in length, soldered to the upper part, and a bent wire or stirrup beneath, to place the coin upon. A slit piece of brass, with a lateral screw to hold the coin tight, though in fact conducing more to the ease than accuracy of the experiment, is mentioned by the author, as being preferable to the stirrup: and, to extend the use of the instrument, he proposes that the ball be made large, and provided with a contrivance for occasionally changing the quantity of ballast applied beneath the ball.

Boyle's instrument was intended to be used in water, and consequently the graduations of its stem denoted certain invariable weights. But when the hydrometer is to be used in various fluids it diminishes the accuracy of the results, if those spaces be taken for absolute weights; or, at all events, it brings forward a rather intricate consideration of the relation which the bulks of the spaces, or parts of the stem, have to the whole immersed part. This appears to have been the inducement that led M. G. Fahrenheit* to add

* Reid and Gray's Abridgment of the Phil. Transf. vol. VI. part I. p. 294.

a small

a small dish or scale to the top of the upper stem, which, instead of graduations, had only a single mark that, in all cases, was to be brought to the surface of the fluid, by means of weights added in the said scale.

Mr. Clarke,* who in the year 1730 published an account of an hydrometer, does not appear to have been apprised of what had been done before by Boyle and Fahrenheit. For he speaks of his own instrument as a new invention, though it does not differ from that of Boyle, except in having a great number of ballast weights to be screwed occasionally to the lower stem, instead of depending on the graduations of the upper stem; and he affirms, that the specific gravities of fluids cannot be found without a great deal of trouble, though it is certain that they may be found with greater ease, and much more accuracy, by that of Fahrenheit, than by his own. Clarke's hydrometer, with weights adapted to allow for the diminution of specific gravity, which arises from the thermometrical expansion of fluids, is used by the officers of excise.

This hydrometer is inferior to Fahrenheit's in two respects. In the first place, either a bubble of air, or a portion of the fluid, will lie hid in that part of the cavity of the ballast weight, which is not filled by the screw; and it

* Ibid. vol. VI. part I. p. 295.

is

is of very different consequence, which of the two is there. And secondly, the weights acting on the instrument, by their residual gravity, will not be constant; or, in other words, an additional weight will be accompanied by an addition to the bulk of the immersed part of the instrument: and, in the case where the specific gravity of the liquid is not given, but required, it will not be easy to determine how much the operation of the one is counteracted by that of the other. However, though this last consideration evinces that the instrument is not fit for general use, yet it is accurate for the trial of ardent spirit, or any other particular liquid, when the weights are adjusted by experiment to the intended use.

Posterior to these, there have been several attempts to improve the hydrometer, but as they have been aimed chiefly to render it more perfect or convenient, with respect to the single use of proving spirits, it is unnecessary to describe them at large. Among these it is however proper to mention those of Dr. G. Fordyce, and Mr. Quin. The first is certainly the most perfect instrument we possess, its weights being adjusted to the different specific gravities of spirits, by experiments made at numerous varieties of strength and temperature. The latter having no additional weights, but depending entirely on the graduations of its stem, is much

more

more ready in practice. All its originality consists in its stem being the frustum of a cone, whose larger end is uppermost, by which happy contrivance the stem is shortened, and its graduations are all kept nearly equal.

I shall now proceed to describe the instrument I have caused to be made for the general purposes of finding the specific gravities of bodies. Its dimensions are likewise added. *

AA represents a small scale. It may be taken off at D. Diameter $1\frac{1}{2}$ inch. Weight 44 grains.

B a stem of hardened steel wire. Diameter $\frac{1}{100}$ inch.

E a hollow copper globe. Diameter $2\frac{8}{10}$ inches. Weight with stem 369 grains.

FF a stirrup of wire screwed to the globe at C.

G a small scale serving likewise as a counterpoise. Diameter $1\frac{1}{2}$ inch. Weight with stirrup 1634 grains.

The other dimensions may be had from the drawing which is $\frac{1}{7}$ of the linear magnitude of the instrument itself.

In the construction, it is assumed that the upper scale shall constantly carry 1000 grains when the lower scale is empty, and the instru-

* See the figure to which these letters refer in plate II. vol. II.

ment

ment sunk in distilled water at the temperature of 60° Fahrenheit, to the middle of the wire or stem. The length of the stem is arbitrary, as is likewise the distance of the lower scale from the surface of the globe. But the length of the stem being settled, the lower scale may be made lighter, and, consequently, the globe less, the greater its distance is taken from the surface of the globe; and the contrary. It is to be noted that the diameter of each scale must not be less than the side of a cube of water weighing 1000 grains.

The distances of the upper and lower scales, respectively, from the nearest surface of the globe being settled, add half the side of a cube of water weighing 1000 grains to the distance of the upper scale. This increased distance, and the said distance of the lower scale, may be considered as the two arms of a lever; and, by the property of that mechanical power,

As the number expressing the lower distance

Is to the whole weight above; namely 1000 grains added to the weight of the upper scale,

So is the number expressing the upper distance,

To the lower weight, when the instrument has no tendency to any one position.

This last found weight must be considerably increased, in order that the instruments may acquire and preserve a perpendicular position.

Add together, into one sum, the weight of the lower

scale thus found, the weight of the upper scale and its load, and the estimate weight of the ball and wires. Find the solid content of an equal weight of water; and thence, by the common rules of mensuration the diameter of an equal sphere. This will be the diameter, from outside to outside, of the globe that will float the whole.

As this process, and every other part of the present letter, may be easily deduced from the well known laws of hydrostatics; I forbear enlarging on the demonstrative part, and shall proceed to indicate the use of the instrument in the same cursory manner.

To measure the specific gravities, and thermometrical expansions, of FLUIDS. If the extreme length or heighth of the instrument be moderate, its weight, when loaded, will be about 3100 grains. It is, however, necessary in practice, that its weight should be accurately found by experiment. This whole weight is equal to that of a quantity of distilled water, at the temperature of 60°, whose bulk is equal to that part of the instrument which is below the middle of the stem. If, therefore, the instrument be immersed to the middle of the stem, in any other fluid at the same temperature (which may be done by altering the load) the difference between this last load and 1000 grains, will be the difference

ence between equal bulks of water, and of the other fluid, the weight of the mass of water being known to be 3100 grains. If the said difference be *excess* above 1000 grains it must be added, or if it be *defect* subtracted from 3100 grains: the sum or remainder will be a number, whose ratio to 3100 will express the ratio of the specific gravity of the assumed fluid to that of water. And this ratio will be expressed with considerable accuracy; for the instrument having a cylindrical stem of no more than $\frac{1}{40}$ of an inch diameter, will be raised or depressed near one inch by the subtraction or addition of $\frac{1}{10}$ of a grain, and will therefore indicate with ease such mutations of weight as do not fall short of $\frac{1}{20}$ of a grain, or $\frac{1}{62000}$th part of the whole. Consequently, the specific gravities of all fluids, in which this instrument can be immersed, will be found to five places of figures.

It is evident, that this instrument is a kind of *thermometer*, perhaps better adapted than the common one, for measuring the expansions of fluids by heat. As the fluid, in the common thermometer, *rises* by the excess of expansion of the fluid beyond the expansion of the glass vessel, so our instrument will *fall* by the excess of the same expansion, beyond the proper expansion of the materials it is composed of.

To *measure the specific gravities* of SOLID BODIES. The solid bodies, to be tried by this instrument,

must not exceed 1000 grains in weight. Place the instrument in distilled water, and load the upper scale or dish, till the surface of the water intersects the middle of the stem. If the weights required to effect this be exactly 1000 grains, the temperature of the water answers to 60° of Fahrenheit's scale; if they be more or less than 1000 grains, it follows, that the water is colder or warmer. Having taken a note of this weight, unload the scale, and place therein the body, whose specific gravity is required. Add more weight, till the surface of the water again bisects the stem. The difference between the added weight, and the former load, is the weight of the body in air. Place now the body in the lower scale or dish under water, and add weights in the upper scale, till the surface of the water once more bisects the stem. This last added weight will be the difference between 1000 grains, and the weight of the body in water. To illustrate this by an example.

N. B. The specific gravity of lead and tin, (and probably other metals) will vary in the third figure, when the same piece of metal is melted and cooled a second time. This difference probably arises from the arrangement of the parts in cooling more or less suddenly.

The

The load was found by experiment	999	:	10 grains.
A piece of caſt lead required the additional weight	210	:	85
Difference is abſolute weight in air	788	:	25
Additional weight when the lead was in the lower ſcale	280	:	09
Difference between the two additional weights or loſs by immerſion	69	:	24

Hence ſpecific gravity $\frac{788.25}{69.24}$ $\frac{11384}{1000}$

When the inſtrument is once adjuſted in diſtilled water, common water may be afterwards uſed. For the ratio of the ſpecific gravity of the water made uſe of to that of diſtilled water being known $(=\frac{b}{a})$, and the ratio of the ſpecific gravity of the ſolid to the water made uſe of being alſo known $(=\frac{c}{b})$, the ratio of the ſpecific gravity of the ſolid to that of diſtilled water will be compounded of both (that is, $\frac{cb}{ab}$).

There is reaſon to conclude from the experiments of various authors, that they have not paid much attention either to the temperature or ſpecific gravity of the water they made uſe of. They who are inclined to be contented with a leſs degree of preciſion than is intended in the conſtruction here deſcribed, may change the ſtem, which for that purpoſe may be made to take out, for a larger.

One

One of the greateſt difficulties that attends hydroſtatical experiments, ariſes from the attraction or repulſion that obtains at the ſurface of the water. After trying many expedients to obviate the irregularities ariſing from this cauſe, I find reaſon to prefer the ſimple one, of carefully wiping the whole inſtrument, and eſpecially the ſtem, with a clean cloth. The weights in the diſh muſt not be eſteemed accurate, while there is either a cumulus, or a cavity, in the water round the ſtem.

I am, Dear Sir,

Your affectionate humble ſervant,

WILLIAM NICHOLSON.

London, *June* 1, 1784.

THE END.