What a load of Twaddell

David G Rance

For most, twaddell is an outdated expression to describe some written or spoken gibberish but even if it sounds too ridiculous for words, it is also the name of a special scale for measuring the strength or concentration of liquids.

Twaddell, Twaddle, Twattle or Tattle?

The English language is blessed with a rich vocabulary and a wealth of colourful colloquialisms, sayings and quotations. Today the modern equivalent of twaddle is the less elegant *"bullshit"*. However, Etymologists are more likely to cite *babble, chatter, balderdash, bilge* or even *nonsense* as suitable synonyms. The origins of twaddle as a term for gibberish is largely unknown but it may have evolved from the 16th century old-English word: *twattle or tattle*. Indeed a term forever synonymous with idle gossip is: *"tittle-tattle"*.

**Iconic 1940's UK
Min. of Information poster**

Whatever its origins, Twaddell is also the name of a special scale devised at the beginning of 19th century and popular with industry for determining the strength or concentration of liquids. Perhaps surprisingly, there was even a Twaddell slide rule.

William Twaddell

This surprising story starts with respected Glaswegian glass-blower and renowned hydrometer maker: William Twaddell (fl. 1792-1839). Being Glasgow based later plays a significant role in how Twaddells became popular. He learnt his trade and worked for many years for the renowned Glasgow instrument maker James Brown. After succeeding his mentor, William Twaddell first used his glass-blowing skills to make sets of "Philosophical bubbles" before making hydrometers – one special hydrometer was even named after him.

Image:
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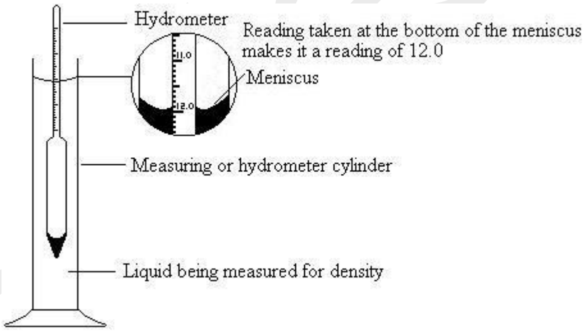
The set shown comprises of 18 glass philosophical bubbles or specific gravity beads and was made around 1790. It is not easy to see but "TWADDELL LATE BROWN IN THE TRONGATE GLASGOW" is stamped on the inside of the lid. Each bead was calibrated differently so that they neither rose nor sunk when in a liquid with a specific gravity that exactly matched the pre-set calibration. The idea for philosophical bubbles probably came from Florence, Italy during the Renaissance period. Later they were (re)invented and made fashionable by another Glaswegian, Alexander Wilson in the 1750s. They were mainly used in the spirits and distilling industry.

Specific Gravity

Relative density or specific gravity is the density of a substance compared to a reference material, liquid or gas. For liquids the specific gravity (SG) value is its density relative to pure water at a given temperature. Historically for most liquids in the UK, except for proof spirit, this was 60ºF. So if a liquid's relative density is less than one, then it is less dense than water and if greater than one, it is said to be denser than water. This is why crude oil, with an SG rating of about 0.9, floats on top of water and mercury, with an SG rating of 13.6, sinks to the bottom in water.

In William Twaddell's day (as now) relative density was commonly used in many heavy industries as a means to determine the strength of a solution of various substances such as brines, sugar solutions (syrups, juices, honeys, brewers wort, must, etc) and acids. An alternative to calibrated SG beads that was invented much earlier and "outlived" SG beads was the hydrometer. Today usually made of glass (early versions were mostly made of metal), a hydrometer consists of a cylindrical stem and a bulb weighted with mercury or lead shot to make it float upright.

For convenience, to test a liquid for its SG value a sample is usually poured or syphoned off into a measuring or hydrometer cylinder and a hydrometer gently lowered into the liquid until it floats freely. The relative density or "strength" of the liquid will determine how much the stem of the hydrometer is above (and below) the surface of the liquid. So a paper scale is usually placed inside the glass stem so an accurate SG reading can be directly taken. Over the years various scales, usually for specific types of liquids prevalent to particular industries, have been devised to work in combination with specially calibrated types of hydrometers - e.g. saccharometers, lactometers and brineometers.



Industry-specific SG for liquids

Clearly relative density was a universal reference scale. However, for many industries and industrial processes the SG scale had two major drawbacks: (i) it needed "laboratory precision" and (ii) the limited range of the scale. As SG values are often expressed to an accuracy of 2 or 3 decimal places, it is difficult to an untrained eye and without specialist equipment to take such accurate hydrometer readings outside a laboratory. For liquids, the range of the SG scale naturally has to cater for the lightest and heaviest relative to water. However, for some industries only a small part of the SG scale is ever needed. In such cases just the needed part of the SG scale was expanded/exploded to create a much bigger and easier to use industry specific range. This led to industry specific scales being developed and naturally hydrometers calibrated to these scales coming on to the market.

SCALE	INVENTED OR INSPIRED BY	YEAR	USED IN	UNIT
Alcohol by proof	English Excise specialist **Bartholemew Sikes**	from 1817	Customs & Excise / Alcohol industry	% Proof
Baumé or Degrees Baumé	French pharmacist **Antoine Baumé**	1768	Many industries including wine making	B°, Be°, Bé°
Brewers pounds per barrel	English brewing theorist **John Richardson**	1784	Alcohol and brewing industry	br.lb./brl
Brix or Degrees Brix	German mathematician **Adolf Brix**	circa 1830	Wine making, starch & sugar industries	°Bx
Oechsle or Degrees Oechsle	German inventor **Christian Oechsle**	circa 1820	Wine making	°Oe
Plato or Degrees Plato	German scientist **Fritz Plato**	circa 1900	Brewing industry	°P

Table 1: **Examples of a few Industry specific SG-based scales**

Twaddells

Missing from Table 1 is a scale little known outside the UK: the **Twaddell scale**. Typically the scale runs from 0 to approximately 170 degrees Twaddell or °Tw. The formula for the scale is:

$$°Tw = 200 \left(\frac{weight\ of\ volume\ of\ liquid\ @\ 60°F}{weight\ of\ equal\ volume\ of\ pure\ water\ @\ 60°F} - 1 \right)$$

For the purpose of this article, the formula can be more simply expressed as:

$$°Tw = 200\ (SG - 1)$$

The formula reveals that the °Tw scale was ideal for liquids with an SG range of between 1.00 and 1.85 – i.e. a range for liquids heavier than water. For example, the acids used in the tanning industry or the alkaline lyes used in papermaking. Twaddells and °Tw were named after hydrometer maker William Twaddell or possibly his successor: Thomas Twaddell (fl. 1840-1848).

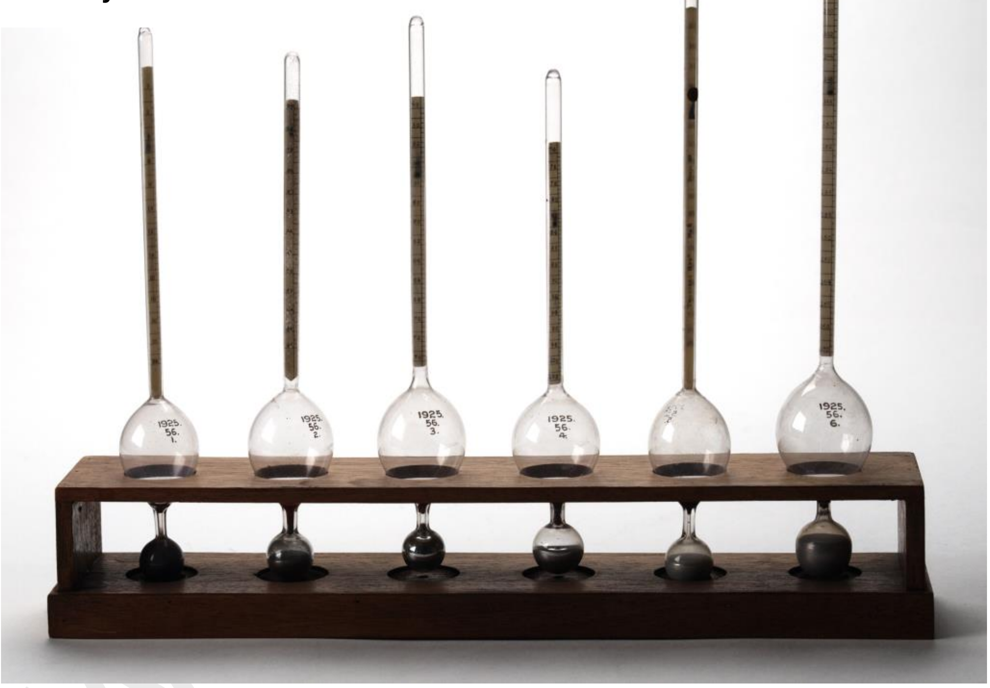


Image:
courtesy of © NMS

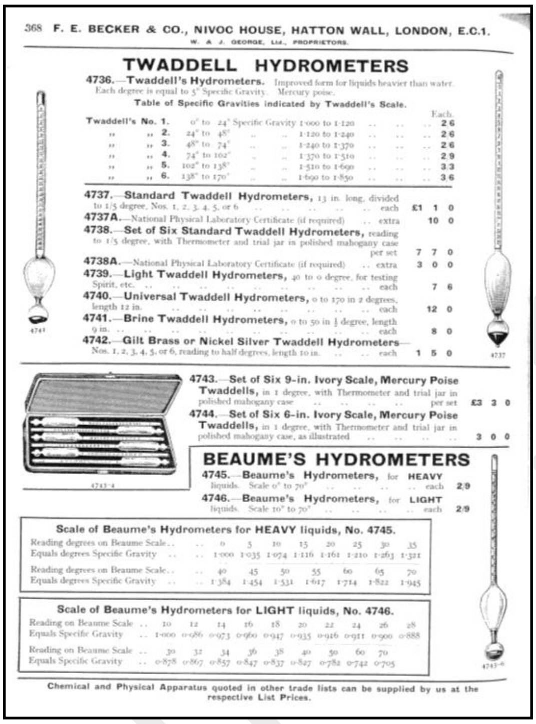
This early set made by William or Thomas Twaddell dates from around 1840. Conventionally the full range of 0 - 170 °Tw is divided over six differently calibrated hydrometers.

Hydrometer #	°Tw	SG range
No. 1	0 - 24	1.00 - 1.12
No. 2	24 - 48	1.12 - 1.24
No .3	48 - 74	1.24 - 1.37
No. 4	74 - 102	1.37 – 1.51
No. 5	102 - 138	1.51 - 1.69
No. 6	138 - 170	1.69 - 1.85

Table 2: **Calibration of a standard set of six Twaddell hydrometers**

Sets from later 19th and 20th century instrument makers, as shown by the adjoining page out of F.E. BECKER & CO. 1929 catalogue, continued the convention of selling Twaddell hydrometers as sets of six. However, single numbered Twaddell hydrometers are also offered for sale. For some industries or processes a single or a pair of Twaddell hydrometers covering a specific °Tw range could have been enough to monitor and control the strength of a particular liquid, solution or effluent. "Kew Certified" sets or individual hydrometers were more expensive verified[1] versions used for more accurate work or to the check the accuracy of the hydrometers used on a daily basis. New numbered Twaddell hydrometers are still being sold.

However, despite being named after the maker of the first set of Twaddell hydrometers, neither William nor Thomas Twaddell was the inventor of the Twaddell scale. That honour is thought to belong to yet another Glaswegian, the chemist and renowned inventor of waterproof fabrics: Charles Macintosh (1766 – 1843).



368 F. E. BECKER & CO., NIVOC HOUSE, HATTON WALL, LONDON, E.C.1.
W. & J. GEORGE, Ltd., PROPRIETORS.

TWADDELL HYDROMETERS

4736.—Twaddell's Hydrometers. Improved form for liquids heavier than water. Each degree is equal to 5° Specific Gravity. Mercury poise.

Table of Specific Gravities indicated by Twaddell's Scale.

			Each.
Twaddell's No. 1.	0° to 24° Specific Gravity	1·000 to 1·120	2/6
„ „ 2.	24° to 48°	1·120 to 1·240	2/6
„ „ 3.	48° to 74°	1·240 to 1·370	2/6
„ „ 4.	74° to 102°	1·370 to 1·510	2/9
„ „ 5.	102° to 138°	1·510 to 1·690	3/3
„ „ 6.	138° to 170°	1·690 to 1·850	3/6

4737.—Standard Twaddell Hydrometers, 13 in. long, divided to 1/5 degree, Nos. 1, 2, 3, 4, 5, or 6 .. each £1 1 0
4737A.—National Physical Laboratory Certificate (if required) .. extra 10 0
4738.—Set of Six Standard Twaddell Hydrometers, reading to 1/5 degree, with Thermometer and trial jar in polished mahogany case per set 7 7 0
4738A.—National Physical Laboratory Certificate (if required) .. extra 3 0 0
4739.—Light Twaddell Hydrometers, 40 to 0 degree, for testing Spirit, etc. .. each 7 6
4740.—Universal Twaddell Hydrometers, 0 to 170 in 2 degrees, length 12 in. .. each 12 0
4741.—Brine Twaddell Hydrometers, 0 to 50 in ½ degree, length 9 in. .. each 8 0
4742.—Gilt Brass or Nickel Silver Twaddell Hydrometers—Nos. 1, 2, 3, 4, 5, or 6, reading to half degrees, length 10 in. .. each 1 5 0

4743.—Set of Six 9-in. Ivory Scale, Mercury Poise Twaddells, in 1 degree, with Thermometer and trial jar in polished mahogany case .. per set £3 3 0
4744.—Set of Six 6-in. Ivory Scale, Mercury Poise Twaddells, in 1 degree, with Thermometer and trial jar in polished mahogany case, as illustrated .. 3 0 0

BEAUME'S HYDROMETERS

4745.—Beaume's Hydrometers, for HEAVY liquids. Scale 0° to 70° .. each 2/9
4746.—Beaume's Hydrometers, for LIGHT liquids. Scale 10° to 70° .. each 2/9

Scale of Beaume's Hydrometers for HEAVY liquids, No. 4745.

Reading degrees on Beaume Scale	0	5	10	15	20	25	30	35
Equals degrees Specific Gravity	1·000	1·035	1·074	1·116	1·161	1·210	1·263	1·321
Reading degrees on Beaume Scale	40	45	50	55	60	65	70	
Equals degrees Specific Gravity	1·384	1·454	1·531	1·617	1·714	1·822	1·945	

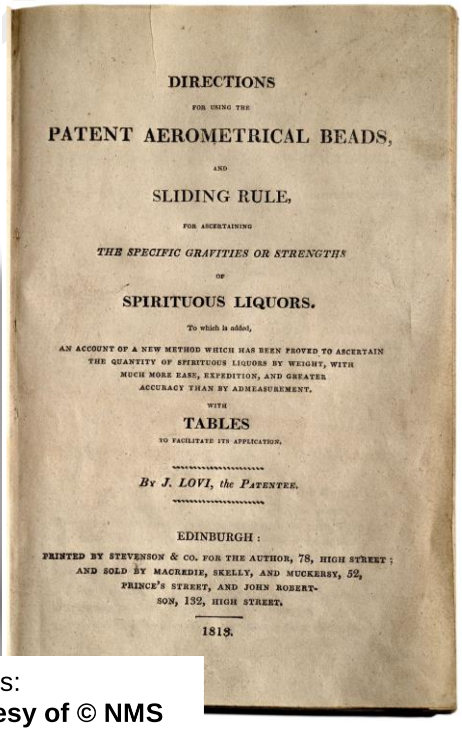
Scale of Beaume's Hydrometers for LIGHT liquids, No. 4746.

Reading on Beaume Scale	10	12	14	16	18	20	22	24	26	28
Equals Specific Gravity	1·000	0·986	0·973	0·960	0·947	0·935	0·916	0·911	0·900	0·888
Reading on Beaume Scale	30	32	34	36	38	40	50	60	70	
Equals Specific Gravity	0·878	0·867	0·857	0·847	0·837	0·827	0·782	0·742	0·705	

Chemical and Physical Apparatus quoted in other trade lists can be supplied by us at the respective List Prices.

Slide Rule for Twaddells

Understandably not long after Alexander Wilson reinvented SG beads, slide rules were synonymous with calculations involving the SG of liquids.



DIRECTIONS
FOR USING THE
PATENT AEROMETRICAL BEADS,
AND
SLIDING RULE,
FOR ASCERTAINING
THE SPECIFIC GRAVITIES OR STRENGTHS
OF
SPIRITUOUS LIQUORS.
To which is added,
AN ACCOUNT OF A NEW METHOD WHICH HAS BEEN PROVED TO ASCERTAIN THE QUANTITY OF SPIRITUOUS LIQUORS BY WEIGHT, WITH MUCH MORE EASE, EXPEDITION, AND GREATER ACCURACY THAN BY ADMEASUREMENT.
WITH
TABLES
TO FACILITATE ITS APPLICATION.

By J. LOVI, the Patentee.

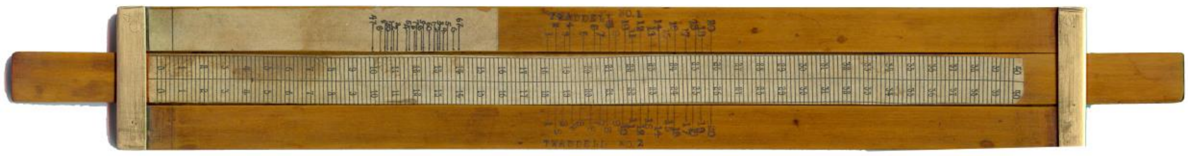
EDINBURGH:
PRINTED BY STEVENSON & CO. FOR THE AUTHOR, 78, HIGH STREET; AND SOLD BY MACREDIE, SKELLY, AND MUCKERSY, 52, PRINCE'S STREET, AND JOHN ROBERTSON, 132, HIGH STREET.
1813.

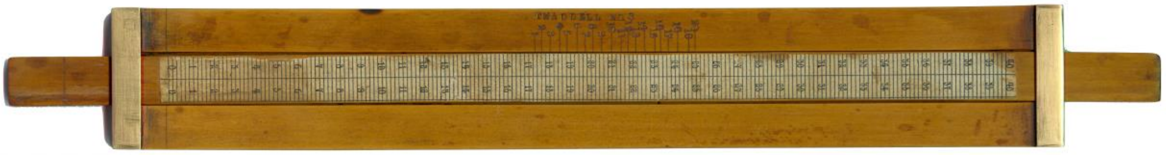
Images:
courtesy of © NMS

The impressive set shown has 363 SG beads and was probably made in Edinburgh around 1810 by Isabella Lovi. From the instructions, the accompanying slide rule (made from bone) played a key part in finding out the SG strength of "Spirituous Liquors" and possibly for a wide assortment of liquids in

[1] Later the Kew UK verification standard was renamed to the NPL (National Physical Laboratory).

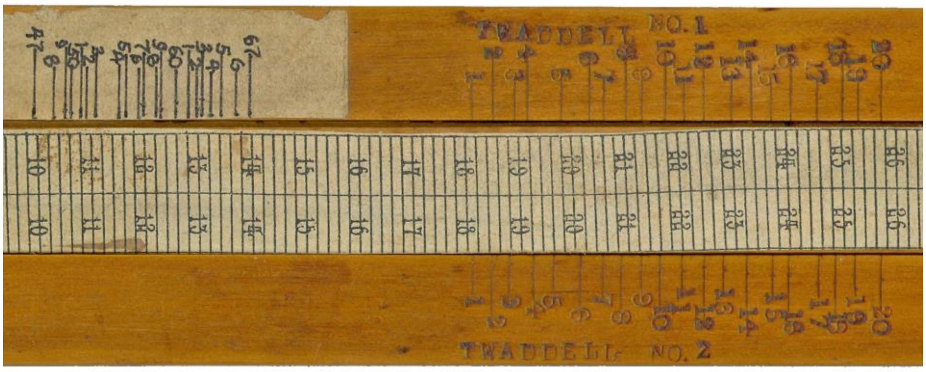
many industries. However, the *raison d'être* of the later Twaddell scale was always its simplicity – simple to use and simple to calculate with. So a slide rule for calculating in just °Tw is somewhat counter-intuitive. So when one came up for sale on eBay® in 2009 it caught my eye and is now part of my collection.





It is a boxwood duplex rule with brass straps to protect each end of the stock. Not uncommonly there is no maker's name, mark or number but it looks like some of the smaller alcohol proof rules. The stock is 9 x 1⅜ x ⅛ inches but compared with the stock, the oversized slide is a full 10¾ inches long. The rule carries a mixture of stamped/incised scales and glued on paper printed scales.

On both sides of the slide is an identical glued paper linear "0 to 40" scale. On one side of the stock there are two identical short mirror-image "1 to 20" stamped/incised linear scales, respectively labelled "TWADDELL NO. 1" and "TWADDELL NO. 2". To the left of the "TWADDELL NO. 1" scale, there is an extra unlabelled glued paper irregular scale running from "47 to 67".



On the other side of the stock is another identical stamped/incised "1 to 20" linear scale labelled: "TWADDELL NO. 3".

The linear nature of the Twaddell labelled scales was no surprise but why they are numbered differently but cover the same range is a mystery. The identical linear scale on both sides of the slide is almost as much of a mystery. Speculatively the traditional range spanned by Twaddell No. 1 to.3 hydrometers is 0 to 74°Tw. The corresponding SG range is 1.00 to 1.37 – discounting the significant integer, the "0 to 40" could correspond to the SG range that equates to the standard Twaddell No. 1 to 3 hydrometer range. But even then I cannot fathom out how the slide interacts with any of the scales on the stock – especially the other glued paper 47 - 67 scale.

The rule is somewhat crudely made but too good to be home-made. The style of lettering would seem to suggest it dates from the mid 19th century through to early 20th century.

Practical use

At first, perhaps like many readers of this article, I almost dismissed °Tw as an eccentric idea that never caught on. This is certainly not the case. It is true that because of its overwhelmingly Glaswegian roots, it first became popular in Scotland before spreading south and its use becoming popular in many types of heavy industry in the UK. It appears never to have caught on in the same way in Europe or other parts of the world but in its UK homeland, it is still being used today.

Generally outside the drink and medical branch, when it comes to making or mixing liquids, industrial processes involve large batches within predefined tolerances. But work orders for batches of liquids expressed in complicated SG terms were rarely practical for the "hands-on" nature of the shop floor. So for production processes involving heavier than water liquids[2], °Tw was ideal i.e. no need for tricky hydrometer readings to 2 or 3 decimal places or mixed integer and decimal fraction calculations.

Use in the Tanning industry:

One well documented case comes from the Tanning industry. Forty years ago a company, based in the North of England, was manufacturing synthetic tanning agents - sulphonation of phenol and related tar acids followed by a formaldehyde condensation. At the end of the process each batch of 2,000 gallons had to be made up to the desired acidity and strength. The acidity was determined by titration but the strength was determined by Twaddells – e.g. the desired strength needed to be 40°Tw. Batches were purposely made slightly over strength so that at the end of the process the desired strength could be attained by diluting the mix with extra water. Using Twaddells the final adjustment[3](s) needed for the strength were simple and easy to calculate:

$$\textit{Extra water needed} = V\,\frac{(Tw - Tw')}{\mathrm{Tw'}}$$

Where: **Tw** = original strength in degrees Twaddell
Tw' = desired strength in degrees Twaddell
V = original volume of the batch (any units)

In this case study of 2000 gallons, the desired strength was 40°Tw but let us say the original strength of the batch came out at 42°Tw. The shop floor could easily do the calculation, 2000 x (42-40) / 40, and add the needed extra 100 gallons of water to dilute the batch to the required °Tw strength. Clearly this way of working is much, much easier than doing the equivalent in SG-based units and admirably demonstrates why Twaddells became popular.

Use in the Pottery industry:

Another, perhaps more unexpected, example of how the Twaddel scale was (and probably still is) used is the Pottery industry in the UK. As part of any industrial casting process, pottery slip is poured into moulds. The aim is to deflocculate the slip so that a high solids concentration is achieved while the slip remains pourable. This shortens the time required to cast to a specified thickness and reduces the water absorbed by the mould. This in turn cuts down the drying time of the mould after use. To get the desired viscosity of slip the deflocculant of choice is sodium silicate (Na_2SiO_3) – perhaps by some better known as "water glass".

Potteries buy sodium silicate in bulk but concentrations can vary. At a pottery the *"Slipmaker"* is responsible for calculating how much sodium silicate to add to the clay suspension to achieve a slip of the desired viscosity. The volume added is dependent on the concentration of the sodium silicate which is expressed in °Tw. As in the tanning industry, knowing the concentration of the sodium silicate in °Tw, the volume to add is easily calculated using Twaddles.

Last laugh on me?

Clearly Charles Macintosh was a practical man and the simplicity of his Twaddell scale is why it became so well-liked in heavy industries, at least in the UK. But perhaps my Twaddell slide rule is (fittingly) nothing more than a bit of gibberish?

As the rest of the story holds up, I have a strong suspicion that in the same way Gunter rules were originally conceived to, among other uses, help more seafaring personnel navigate, my Twaddell slide rule may have been devised to help more shop-floor production workers control the strength of the heavy industry liquids they were making or mixing.

[2] Hydrometers calibrated for a "lighter than water version" of Twaddells were used for testing spirits.
[3] Mostly one adjustment was all that was needed to get the batch to get the desired °Tw strength.

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Would any reader who can make any sense (even in part) of my Twaddell slide rule please contact the author (david.rance@xs4all.nl) and put him out of his misery!

Acknowledgements and References

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- **Tom Martin:** the "oracle of all things liquid" for lots of help and guidance with all the technical and industry related aspects and the image from the F.E. Becker & Co. catalogue.
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- **National Museums of Scotland (NMS)**: for permission to reproduce copyrighted images of items held in their collection.

1. Bryden, D.J.: *"Scottish Scientific Instrument Makers 1600-1900"*, Royal Scottish Museum Information Series, Edinburgh, 1972.
2. National Museums of Scotland: on-line collections database -
   http://www.nms.ac.uk/our_collections.aspx
   http://nms.scran.ac.uk/database/record.php?usi=000-100-104-256-C
   http://nms.scran.ac.uk/database/record.php?usi=000-190-004-180-C
   http://nms.scran.ac.uk/database/record.php?usi=000-100-104-227-C
3. Martin, Tom: *"Help – Slide Rules and Hydrometers"*, UKSRC Skid Stick No. 18, ISSN 1466-3570, September 2004, Pg. 1.
4. Crowther, Paul: *"Feedback – Slide Rules and Hydrometers"*, UKSRC Skid Stick No. 19, ISSN 1466-3570, February 2005, Pg. 3.
5. Stancey, Gerald: *"Feedback – Twaddells"*, UKSRC Skid Stick No.20, ISSN 1466-3570, June 2005, Pg. 7.
6. Martin, Tom: *"Hydrometry and Slide Rules in Brewing and Distilling"*, Proceedings of the 11th International Meeting of Slide Rule Collectors, England, October 2005, Pg. 51.
7. Martin, Tom: *"Alcoholometers and their Slide Rules"*, Proceedings of the 14h International Meeting of Slide Rule Collectors, England, September 2008 Pg. 152.
8. Thomson, R.D.: *"Cyclopaedia of Chemistry"*, London and Glasgow, 1854, pg. 291.
9. Van Poelje, Otto: *"Gunter Rules in Navigation"*, Proceedings of the 9th International Meeting of Slide Rule Collectors, The Netherlands, September 2003, Pg 15.

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