Clues to the kludonometer...

Maria-Theresia Walach, Melanie Cookson-Carter and Rachel Roberts discuss the life work of Captain William Nelson Greenwood, whose legacy includes a mysterious tide calculator

1 *William Nelson Greenwood (1839–1906), sometime third officer on the Cunard Liner, correspondent of Charles Dickens and inventor of 'kludonometrics'* (Lancashire County Council, Red Rose Collections)

Captain William Nelson Greenwood was born in Milnthorpe, north of the northern port town of Lancaster, in 1839. Lancaster had found its heyday in the 18th century, when trade was complex and flourishing. Cotton was shipped in to serve many of the Lancashire cotton mills, and Lancaster was the fourth most prolific port in the transatlantic slave trade. In the wake of the abolition of this notorious enterprise in 1807, the ship industry turned its attention to serving the large numbers of people embarked on voyages as seafaring passengers.

So it was that William Nelson Greenwood found himself engaged in the immigration and emigration business, as third officer on the Cunard Liner, with which the Royal Astronomical Society still has ties today (Barclay 2023). It was on a return journey on board the SS *Russia* to the UK from America that he made the acquaintance of a passenger of some repute, namely one Charles Dickens (1812–70), who was returning from his second – and very lucrative – American reading tour. Dickens wrote in detail about the journey in the article *Aboard Ship* (Dickens 1868), which was later collected as Chapter XXXI of *The Uncommercial Traveller*, noting a portion of the voyage as: "Very dark, the sea most brilliantly phosphorescent...Vigilant captain on the bridge, vigilant first officer looking over port side, vigilant second officer standing by the quartermaster at the compass, vigilant third officer posted at the stern rail with a lantern...All of a sudden... the third officer's lantern twinkles, and he fires a rocket, and another rocket... A change is expected in the light, but none takes place. 'Give them two more rockets, Mr. Vigilant'..."

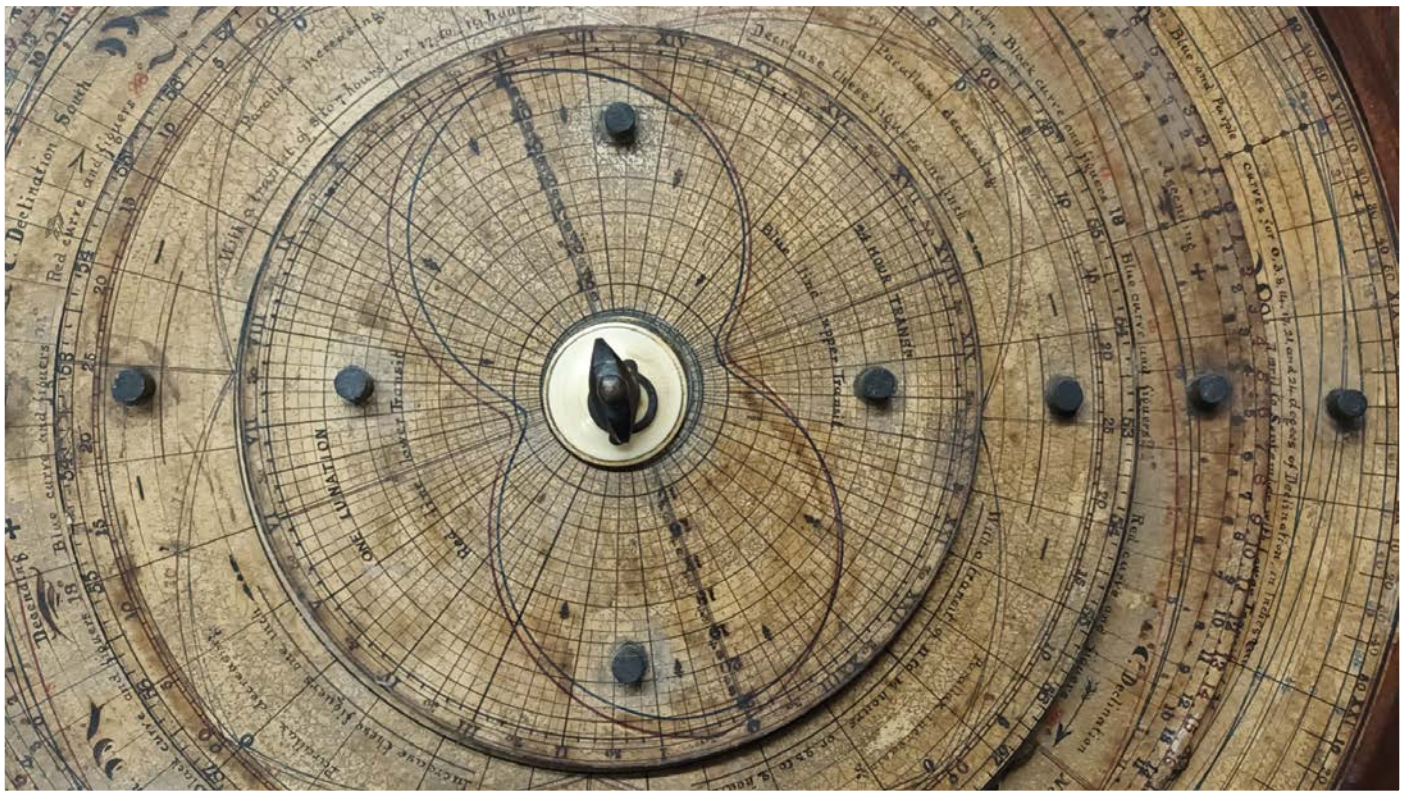
Mr Vigilant was Greenwood, the third officer on this voyage and he must have made quite an impression on Dickens as correspondence between the two followed this exchange.

Eventually, Greenwood settled into a more sedate lifestyle and became the harbourmaster of Lancaster. This shore-based position gave him more time to pursue his scientific interests, including astronomy. Greenwood researched the effects of the sun and moon upon tide phases, and for nearly two decades he produced *Greenwood's Kludonometric Pocket Tide Tables*.

Kludonometrics

Predicting the tides goes back thousands of years, but by the 1870s astronomical theories of the moon and sun had identified the frequencies and strengths of different components of the tide-generating forces.

Greenwood came up with his own coinage for predicting the tides and associated forces: he called it 'kludonometrics'. The name derives



2 A close up of half of the 'kludonometer' transit device, showing all four discs
3 A close-up of the transit device, centred on the innermost disc

from the Greek 'kludon', which appears in the New Testament in reference to surging waves.

Greenwood's career in the merchant navy gave him connections overseas, as he became a corresponding member of the Royal Astronomical Society of Canada, as well as being a Fellow of the Royal Geographical Society, and a member of the Manchester Geographical Society and the Lancaster Philosophical Society closer to home.

Greenwood was very engaged in scientific discourse, and reports from the Royal Astronomical Society of Canada mention him. He was also an active publisher of books, and he used his own money to publish his tide tables. Lancaster Maritime Museum keeps one of the 'Kludonometric Tide Tables', which are now very rare, in its collection. These tide tables are not dissimilar to those available from a small retailer in a seaside resort nowadays, except they were much more detailed. Within them, Greenwood included not only the exact times and dates of tides, but also important navigational information, such as how many lights a harbour had, the colours of the lights, notes of which points were navigable only at high tides, locations of lighthouses, docking charge rates at each port, docking capacity of each port, notes on which ports were unfeasible for large crews, and so on. The end result is not so much a tide table as a directory.

Aside from his kludonometric tide tables, Greenwood also occasionally published on issues of maritime interest. He produced papers on the influence of atmospheric pressure on tides (Nelson Greenwood 1886; 1894a), tidal bores (1894b), and systems for the unification of time measurement at sea (Nelson Greenwood 1895; 1898). He also presented papers to the Lancaster Philosophical Society (presumably appearing in the society's now-lost *Transactions*) on 'The History of a Wave from its Cradle to its Grave' (1888; Nelson Greenwood 1902) and other topics.

Greenwood's mysterious computer

As a Captain and harbour master, Greenwood was very interested in the tides. Predicting tides on a flat and sandy shoreline with estuaries like those at Lancaster is crucial for navigation.

His interest in the tides was evidently highly sophisticated, and had his own manner of personal computer to help him predict them. The circular rule (figures 2 & 3) in the collection of the Lancaster Maritime Museum holds the inscriptions 'W Nelson Greenwood' and 'October 15th 1894'. This device has four independently rotating discs and was made for predicting lunar tides.

The innermost circular disc reads: 'One lunation'

and '24 hour transit' and contains lines reminiscent of two ovoids connected in the middle, which are likely showing the lunar orbit. This was a simplification for a circular orbit. The outer discs are then correction factors to be applied to this initial reading.

From the very neat inscriptions we can ascertain that the second disc accounts for parallax formed by the moon's orbital eccentricity. This refers to the horizontal parallax, or the angle formed by the Earth's semi-diameter and the moon's centre. The third disc makes a correction for the inclination of the moon and the final and most outer disc would have been used to correct for the sun's declination.

This is what we know from the inscriptions and an old newspaper clipping (*Lancaster Gazette* 14 April 1888 n5841 p8). We think he used this device on a desk as it has a solid wooden structure as a base and it was likely built after he had become harbourmaster. From the newspaper clipping, we now know that he called the device a 'kludonometer' and he had it built to predict the tides at Glasson Dock by Lancaster. The article gives an account of his talk to the Lancaster Philosophical Society, where he described the instrument and its workings. He utilised 3526 consecutive tidal observations, each of which he measured several times to minimise random errors, to understand the tidal motions and build the instrument.

Greenwood clearly understood the necessity to predict the tides for commercial purposes and built the kludonometer as a universal way to predict the tides. The newspaper article notes that previous mathematical formulas failed to provide an exact solution to tidal predictions and the most popular publications included calculations which were trade secrets and were 'money-making productions'. It seems that Greenwood was an early adopter of open science and believed that the form of prediction should be made public property and that these works far supersede the protected works in their value and accuracy as tidal predictions. Greenwood describes the kludonometer as a precise instrument: for the 12 months preceding 30 May 1887, the error on the observed tide over the prediction for the lunar tides calculated and corrected for atmospheric influences was 0.01 decimal inches.

Whilst we have now found a description of how the kludonometer was used, we are still looking for more answers. Which of the many numbers and scales are the 'inputs' and 'outputs' of the computer?

Greenwood's circular rule is one of a kind and until very recently, we had no accounts of any instructions. At present we know of no comparable device, and its operation is yet to be tested. This makes this kludonometer ever more mysterious.

Greenwood's legacy

Greenwood, who lived in Lancaster with his wife Elizabeth Mary neé Birchall and two children, had only just been appointed Clerk to the Port Commissioners, when he died suddenly, aged 67. He had hurried to catch a train at Lancaster railway station, and was talking to a colleague when it is reported that he had a severe seizure. There was nothing anyone could do to save him.

Upon his death, *The Nautical Magazine* (1906 v75 p226) wrote: "Those who take an interest in the scientific side of their profession and particularly so in studying the tides, will hear with deep regret of the death of the Lancaster Harbour Master, Captain W. N. Greenwood, F.R.G.S., who expired suddenly in Lancaster Castle Station…He was a man of fine presence and commanded great respect and esteem wherever he went. His loss will be greatly felt."

From the description of Greenwood's talk on the kludonometer in the *Lancaster Gazette* we can be certain that he knew this was not the end to the study of tides. He knew that atmospheric influences on the tides could be erratic and remained a 'vexed question'. Even now, we are still working on understanding vertical atmospheric coupling.

Greenwood left a beautiful object and legacy behind, but this is not the end of the story. We continue to hunt for answers and welcome any information regarding Greenwood or the kludonometer!

4 *Lancaster Maritime Museum (the Old Custom House), Lancaster* (Geni, CC-BY-SA 4.0).

Museum Centenary

Lancaster City Museums are celebrating their 100th anniversary this year. To mark this occasion, Rachel Roberts, the collections registrar of Lancaster City Museums, is releasing 100 podcast episodes about 100 objects in the collection. Each episode pairs one object with a local expert and tells the story of the object. You can listen to the episodes of the series '100 years, 100 objects' online: onehundredyearsonehundredobjects.podbean.com. You might be particularly interested in episode 25, which is about the Tide Tables and episode 38, which is about Captain Greenwood's kludonometer!

As all museums, Lancaster City Museums have a large collection and not all objects are always on display. Whilst the kludonometer is currently not exhibited, it will be on show at Lancaster City Museum as part of an upcoming exhibition celebrating the centenary. The exhibition will open in September and it will be a rare chance to see this astronomical computer in person.

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AUTHORS

Dr Maria-Theresia Walach (m.walach@lancaster.ac.uk) is senior research assistant in the Physics Department of Lancaster University.

Melanie Cookson-Carter (mcooksoncarter@lancaster.gov.uk), following a 30-year career in heritage tourism and museums in the UK and in eastern Canada, is currently manager at the Lancaster Maritime Museum.

Dr Rachel Roberts (rroberts@lancaster.gov.uk) is the Collections Registrar for Lancaster City Museums, dealing with the behind-the-scenes aspects of the historical objects.

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