

Remembering the first battery-operated clock

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Francis Ronalds invented a reliable electric clock in 1815, twenty-five years before Alexander Bain's patent. It was powered by dry piles, a modified form of battery that has extremely long life but the disadvantage that its electrical properties vary with the weather. Ronalds had considerable success in creating regulating mechanisms for his clock to ensure accurate time-keeping in all meteorological conditions. He did not go on to commercialise his ideas, although others made and sold comparable timepieces on the Continent.

This year marks the bicentenary of the publication of the first battery-operated clock. It was rediscovered in the 1970s by Charles Aked, Council member of the Antiquarian Horology Society and first Chairman of the Electrical Horology Group, and further information has since come to hand.¹

The clock was created by a prolific inventor named (later Sir) Francis Ronalds FRS (1788–1873); he lived on the Upper Mall in Hammersmith, London, at the time and a plaque on the house records the pioneering electric telegraph demonstration he performed there the next year.² He had just 'retired' at age twenty-six from running the family's cheesemonger business in Thames Street in order to focus on his first love of electrical science and engineering.

The power source for the clock was a recently developed device called an electric column or dry pile. Volta had described the voltaic pile (now known as the battery) in 1800 — one version comprised a series of zinc and copper (or silver) discs interleaved with cardboard soaked with brine. The dry pile differed in that the paper discs were dry (Fig. 1). It was created with the goal of learning how the battery worked and, in particular, the role of the brine in comparison

with the electrically dissimilar metals. The dry pile was found to have an electric potential difference or voltage across its two ends but, unlike Volta's pile, did not exhibit an electric current when the terminals were joined in a circuit. Its potential difference was also maintained in use whereas a voltaic pile ceased to work after a while.³

Two of the scientists in England who developed and improved the dry pile were Jean-André de Luc (1727–1817) and George Singer (1786–1817). De Luc held the position of Reader to Queen Charlotte in George III's court while Singer delivered science lectures in London and made and sold electrical equipment. Each developed demonstrations of the dry pile in action, using its oppositely charged terminals to drive the motion of a small bead suspended on a silk thread through attraction and repulsion. The bead could also strike two charged bells alternately as a chime.

The electrical properties of the dry pile were quickly found to depend on the temperature and humidity. The aim of Ronalds' first scientific papers in 1814 was to investigate these relationships and their causes, and he sought advice from the two experienced scientists. He soon decided to automate his observations by adopting a

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1. C.K. Aked, 'The First Electric Clock', *Antiquarian Horology*, VIII (1973), 276–89

2. B.F. Ronalds, *The Man who Imagined Today's World of "Electric Conversations" 200 Years Ago: The Story of Sir Francis Ronalds*, to be printed.

3. W. Hackmann, 'The Enigma of Volta's "Contact Tension" and the Development of the "Dry Pile"', *Nuova Voltiana: Studies on Volta and his Times*, 3 F. Bevilacqua, L. Frenonesi (Eds) (2000), 103–19.



Fig. 1. Ronalds' dry piles, manufactured by Singer (1814). Source: Science Museum, reproduced with permission.

similar suspended bead arrangement and attaching it to a pawl-and-ratchet with a dial so that the number of vibrations in any chosen period could be counted.

The obvious idea then hit him of applying the arrangement as an electric clock. First, he added stiffness and weight to the moving element to give it the steady periodicity of a pendulum. The role of the electrical attraction was now primarily to boost the pendulum's natural motion to overcome frictional decay. There were two difficulties to be overcome: the charge needed to be regulated to minimise variations due to the weather and delivered in a way that did not jar the smooth oscillation of the pendulum.

Ronalds trialled numerous solutions to these challenges over the next few years. The approach that he first published on 9 March 1815 in the *Philosophical Magazine* was to prevent contact — the piles discharged the electrified pendulum through a small air gap that was readily

adjustable in width to fine-tune the motion (Fig. 2). The arrangement also allowed any increase in electricity to be counteracted by larger amplitude of vibration and additional charge draw-off through the reduced air gap. A bank of six of Singer's piles formed the power source.⁴ Ronalds acknowledged both Singer's and de Luc's prior work in his paper, noting that he preferred the experimental set up of the latter to the former as the starting point for his own application.

His second mode of weather compensation, also published in the 1815 *Philosophical Magazine*, employed a vertical rod that rested on the surface of the mercury in a large thermometer and was linked to a beam carrying the clock face and pendulum. As the mercury rose, literally, the beam was elevated and the pendulum swung further before being charged by brass plates at an adjustable angle (Fig. 3). The piles were sealed in a box of cement. Ronalds, who always understated

4. F. Ronalds, 'On Electro-galvanic Agency employed as a Moving Power; with a Description of a Galvanic Clock', *Phil. Mag.*, XLV (1815), 261–4.

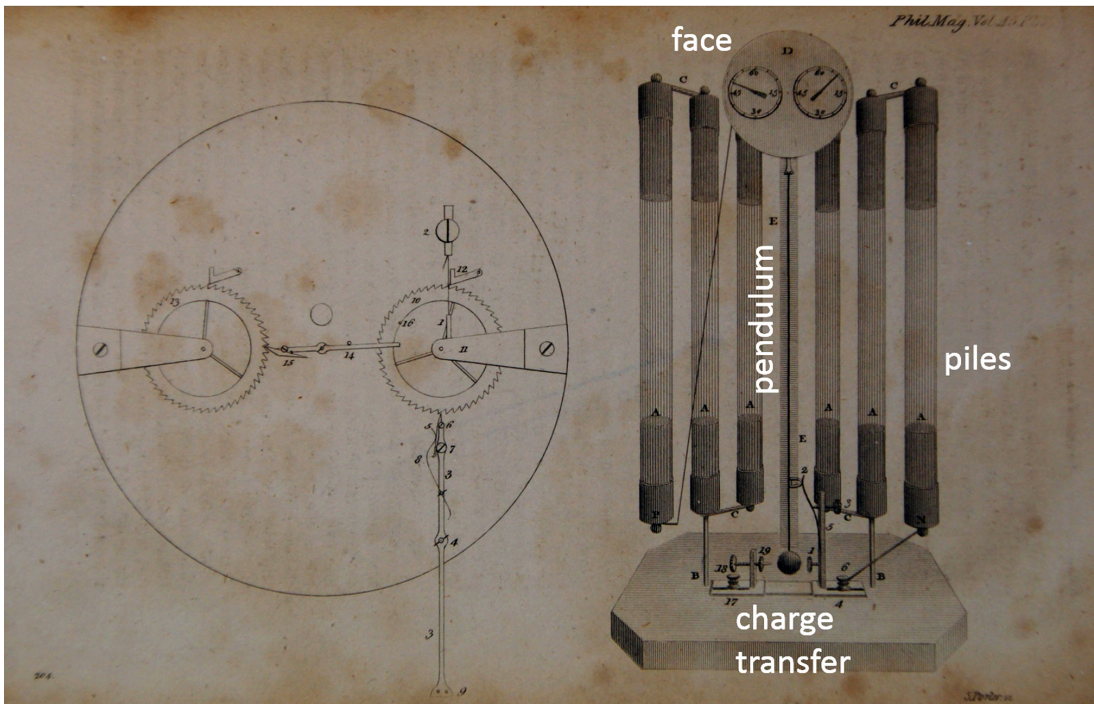
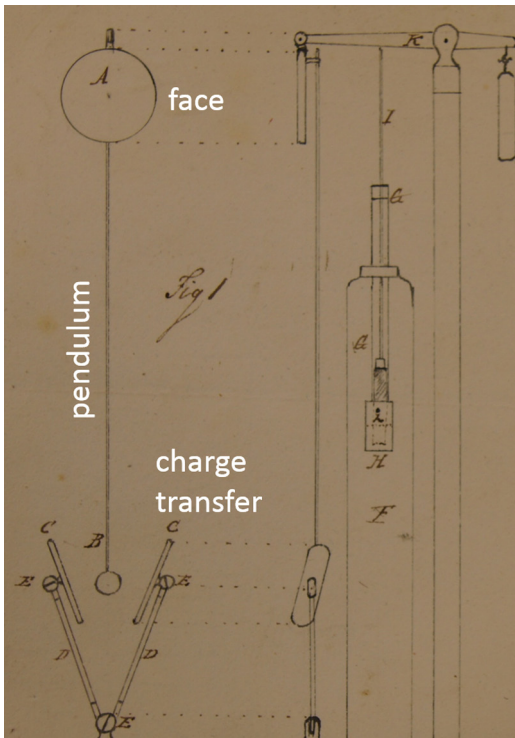


Fig. 2. Battery-operated clock - model 1. Source: *Phil. Mag.* XLV (1815).



Left: Fig. 3. Battery-operated clock - model 2 (1815). Source: Ronalds Archive IET 6.56, reproduced with permission.

his achievements, felt able to record that 'the instrument actually keeps tolerably good time'.⁵

He then reverted to preventing hard contact between the pendulum bob and the charged plates, this time by setting up taut cross wires that cushioned the ends of the swing.⁶ Hand-written results survive from November 1817 in the Ronalds Archive at the Institution of Engineering and Technology (IET) that indicate the clock's net gain or loss over several days to have been just tens of seconds.⁷ In his final configuration, the piles were again cemented into a base box and mechanical effects of delivering electric charge to the pendulum were softened by suspending the contact points by fine flexible wire (Fig. 4). He described the device as 'vibrating seconds as regularly at least as any common clock'.⁶

5. F. Ronalds, 'On Correcting the Rate of an Electric Clock by a Compensation for Changes of Temperature', *Phil. Mag.*, XLVI (1815), 203-4.

6. F. Ronalds, 'Account of an Attempt to Apply M. de Luc's Electric Column to the Measurement of Time, &c', *Descriptions of an Electrical Telegraph and of some other Electrical Apparatus* (1823), 58-83.

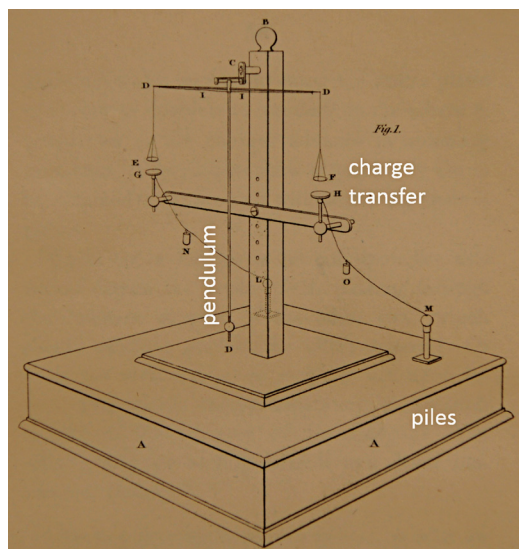


Fig. 4. Battery-operated clock - model 4 (c1818). Source: *Descriptions of an Electrical Telegraph* (1823).

Singer and de Luc both took keen interest in Ronalds' work. The elderly de Luc offered encouragement, while Singer's response was to quickly publish his own paper on the topic of mechanical devices powered by dry piles. Calling Ronalds his pupil, he gave the impression that he had spearheaded Ronalds' endeavours, before condemning the clock as having 'very little chance of becoming at all useful as a time-keeper'.⁸

Ronalds denied in a follow-up paper that he had received ideas from others beyond those he had already cited.⁹ Singer retorted in the *Philosophical Magazine* that the clock was 'an electrical toy' and implied in a long personal attack that Ronalds was

overvaluing his contribution.¹⁰ Nothing could be further from the truth – Ronalds' dominant characteristic was humility. He had just had his first taste of the rather competitive and catty world of science. After Singer's remarks, and the Admiralty the next year calling his telegraph 'wholly unnecessary', Ronalds 'bid a cordial adieu to Electricity' and pursued other interests.¹¹ It was thirty-two years before he published again in the *Philosophical Magazine*.

Through his life, Ronalds seldom pursued commercialisation of his inventions. His goal in developing the clock was simply to show that it was possible to use dry piles to keep time in a way that was largely independent of weather effects. He described his research to contacts in Paris, adding to one, 'if you were to give the subject attention I think a useful instrument might be produced', but there is no evidence that his ideas were adopted directly in the clock-making industry.¹²

Dry pile clocks were turned into practice by Giuseppe Zamboni (1776–1846). Zamboni had created a new dry pile in 1812 that Ronalds noted in his papers could deliver considerably higher electric potential than those made in England. One of Zamboni's associates in Germany advised that he had made a clock using the pile very shortly after Ronalds' first paper was submitted.¹³ The group's early work does not appear to mention attempts to compensate for meteorological variability¹⁴ — the 1817 *Annals of Philosophy* advised of the pile:

7. F. Ronalds, MMS Nov 1817, Ronalds Archive IET 5.56.

8. G.J. Singer, 'The Electric Column considered as a maintaining Power, or First Mover for mechanical Purposes', *Phil. Mag.*, XLV (1815), 359–63.

9. F. Ronalds, 'On the Electric Column of Mr. De Luc', *Phil. Mag.*, XLV (1815), 466–7

10. G.J. Singer, 'Correction of some Errors in Mr. Singer's Paper on the Mechanical Applications of the Electric Column', *Phil. Mag.*, XLVI (1815) 11–12.

11. F. Ronalds, *Descriptions of an Electrical Telegraph and of some other Electrical Apparatus* (1823), 83pp.

12. F. Ronalds, draft letters to unnamed recipients ?/10/1815, 3/11/1815, Ronalds Archive IET 6.56.

13. M. Tinazzi, 'Perpetual Electromotive of Giuseppe Zamboni', *Atti del XVI Congresso Nazionale di Storia della Fisica e dell'Astronomia*, Como (1996).

14. L.W. Gilbert, 'Vorläufige Nachricht von grossen zu Stuttgart ausgeführten trocknen Säulen, und von einer sogenannten electrischen Uhr', *Annalen der Physik*, No 3 (1815), 187–90..

Zamboni's Column. — A great number of papers have been published on this new electrical instrument; but no new fact of any importance has been brought to light... It is needless to notice the clocks that have been constructed by means of this column as a moving power both in this country and in Germany; because it is obvious that the great irregularity in the motion of these pendulums must render such clocks of no real utility.¹⁵

Zamboni's team did achieve subsequent success, however, and several clocks that were originally powered by these piles survive in northern Italy.

Ronalds retained his interest in clocks and dry piles for the rest of his life. He used specially-configured hand-wound timepieces to drive a number of his many later inventions, including his telegraph and automated electric generator in 1816 and, in 1845, the first 'movie camera' to capture

the continuous modulation of meteorological and geomagnetic phenomena. He visited Zamboni's laboratory in Verona in 1820 during his Grand Tour, and again in 1858 where he admired a clock that had been running for fifteen years. Ronalds also kept the piles Singer had made for him and recorded that they were still active nearly forty years later.¹⁶ Two of these same piles are now in the Science Museum in South Kensington. (Fig. 1)

Dry piles enjoyed a resurgence during World War II as a portable voltage source and enthusiasts continue to make them today. The Clarendon Laboratory at the University of Oxford has a chime similar to Singer's that was made in 1840 and continues to work with the original piles.¹⁷ It seems likely that Ronalds' original invention could not only have approached modern battery-operated clocks in terms of short-term reliability, but well exceeded them in long-term reliability.

15. T. Thomson, 'Account of the Improvements in Physical Science during the Year 1816', *Annals of Philosophy*, IX (1817), 1–89.

16. F. Ronalds, copy of letter to H Noad 25/8/1853, Ronalds Archive IET 9.1.

17. A.J. Croft, 'The Oxford Electric Bell', *European Journal of Physics* V (1984), 193–4.