The Evolution of Magnetic Field Measurement: From Historical Instruments to Digital Records

Joey Frost-Xenopoulos

Before the advent of modern digital technology, scientists relied on ingenious, often delicate instruments to measure the Earth's magnetic field. These instruments, used in observatories across the world, were essential in tracking magnetic variations that could offer insight into geomagnetic storms, navigation, and even space weather. Among these, the magnetic instruments used in Toronto and Agincourt stand out for their innovation and precision, yet they also highlight the challenges faced by early geomagnetic observers.

The actual instruments used to record these measurements at the observatories in Toronto, and later Agincourt, used a light source and a pinhole to reveal the light to the photopaper, with the light moving according to the magnetic field oscillations. This resulted in some shading around the line of exposure due to the light spillage and is the cause of the thickness of the exposed lines visible in Figure 1. Yet, this wasn't just a flaw; it was a consequence of how the instruments were designed. The thickened lines, shaded due to the diffraction of light, tell a story of early innovation. The Airy disc diffraction pattern, often seen in the data, reflects the underlying limitations of the setup and represents an engineering compromise. The fact that scientists could make sense of these imperfect lines speaks volumes about the expertise of the early observers.

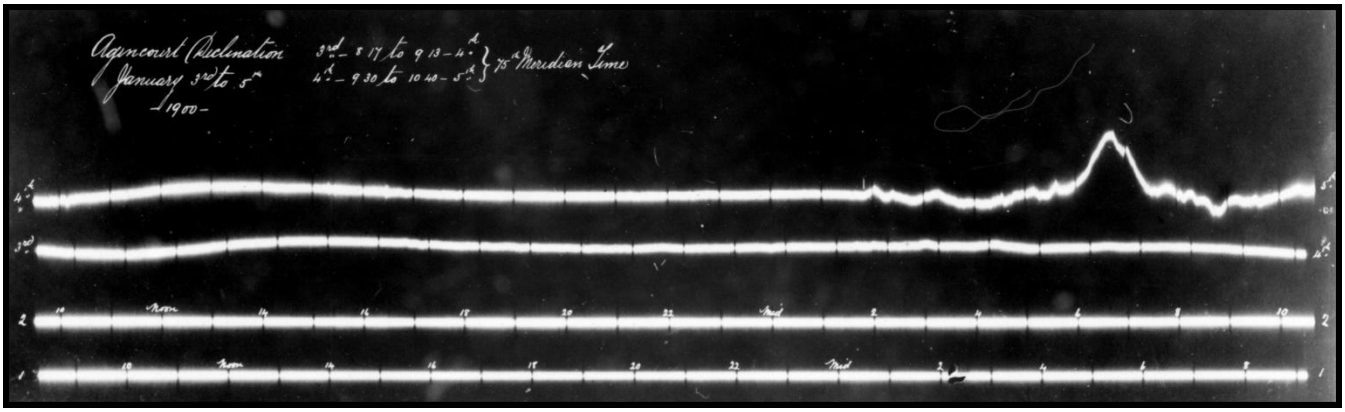

Figure 1: Agincourt, 1900 Declination Magnetogram. The top two irregular curves are the daily magnetic field strength readings, while the bottom two straight lines are the baseline and timing records for the days. The light spillage is evident, resulting in all four lines appearing significantly thicker.

Additionally, the examination of these historic instruments reveals a diversity of approaches, techniques, and makers, reflecting the complexities of practice in observatories and in the field. Thus, pointing to the contingencies that lay hidden below the surface of the historic magnetic traces, adding layers of complexity to the data. The understanding of the physical limitations of the instrumentation and of the approaches has been essential for building the pipeline of digitization, with the end goal being the creation of a full digital record of magnetic field observations back in time over 100 years before digital recordings began.

Figure 2: Dover Dip Circle, an instrument for measuring the inclination during early 20th century magnetic surveys. While innovative for its era, instruments like this required a high level of skill and patience from its users. The lack of modern materials and techniques meant even the smallest of errors could creep into the measurements.

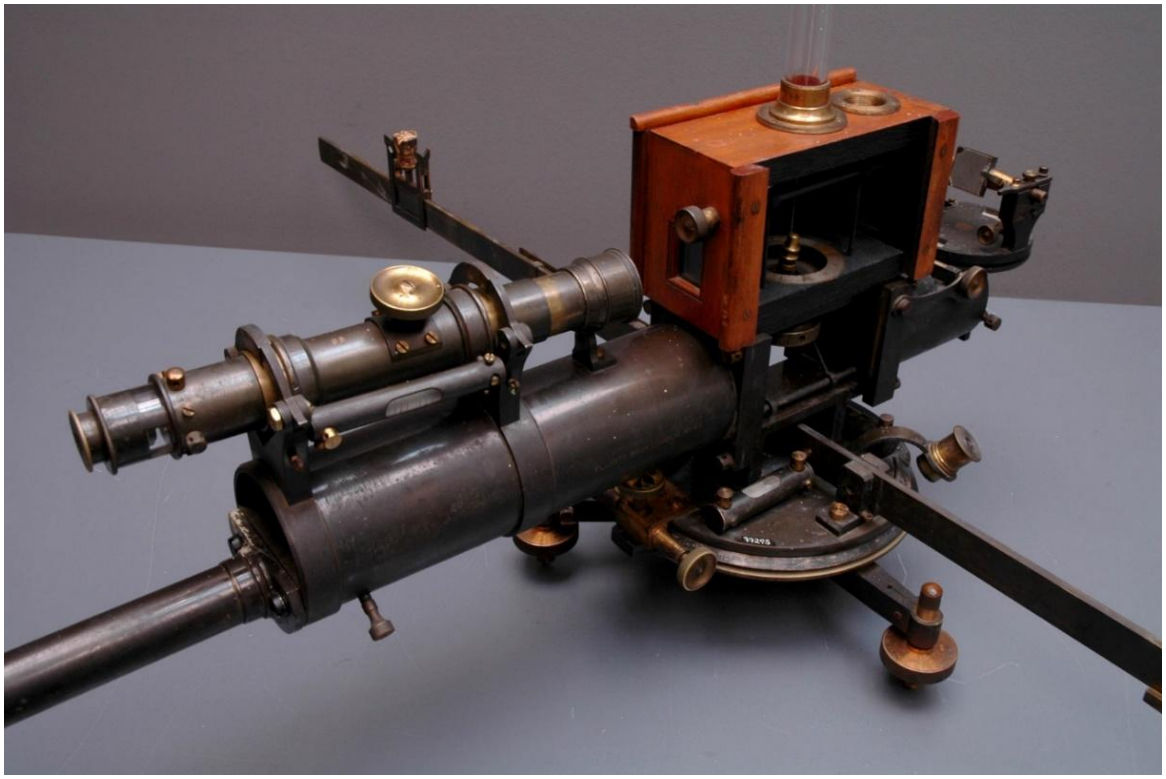

Figure 3: *The Kew Pattern Magnetometer measured the Earth's magnetic field by suspending a magnet inside a rotatable housing and observing its oscillation period through a telescope. This data, combined with a needle deflection experiment, allowed for the precise calculation of the Earth's magnetic field strength. Unlike modern electronic instruments that automatically capture continuous magnetic variations, the Kew magnetometer required manual operation and careful calibration. This highlights the shift from labor-intensive methods to the automated, high-resolution tools used in contemporary geophysics.*

The magnetic instruments of the pre-1940s era reveal not just data about the Earth's magnetic field, but also the ingenuity and determination of early scientists. Their work, now being revived through digitization efforts, continues to inform modern science. As we learn more about these historic instruments and the challenges their operators faced, we uncover the complexities that lie within these magnetic traces, opening new avenues for research and a deeper appreciation for the pioneers of geomagnetic observation.

References

Fair, R. (2011). Inventing Canada: Early Victorian Science and the Idea of a Transcontinental Nation by Suzanne Zeller. *Ontario History*, *103*(2), 228. https://doi.org/10.7202/1065459ar

Gillin, E. J. (2022). The instruments of expeditionary science and the reworking of nineteenth-century magnetic experiment. *Notes and Records the Royal Society Journal of the History of Science*, *76*(3), 565–592. https://doi.org/10.1098/rsnr.2022.0002

Goodman, M. (2018). Follow the data: administering science at Edward Sabine's magnetic department, Woolwich, 1841–57. *Notes and Records the Royal Society Journal of the History of Science*, *73*(2), 187–202. https://doi.org/10.1098/rsnr.2018.0036

Goodman, M. (2017). Scientific Instruments on the move in the North American Magnetic Survey, 1843-1844. *Scientia Canadensis Canadian Journal of the History of Science Technology and Medicine*, *39*(1), 1–26. https://doi.org/10.7202/1041376ar

Figure 2: Government of Canada, Natural Resources Canada, Canadian Hazards Information Service. (2020, October 21). *Dover Dip Circle*. https://geomag.nrcan.gc.ca/lab/vm/dover_dip-en.php

Figure 3: Unknown Manufacturer, *Magnetometer,* between 1900, Artifact no. 1977.0295, Ingenium – Canada's Museums of Science and Innovation, http://collection.ingeniumcanada.org/en/id/1977.0295.001/