The Development of the Gyrocompass – Inventors as Navigators

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Most reference books or monographs about the history of the gyrocompass portray individual inventors, each as an inventive genius, respected as a national hero and probably depicted creating novelties in 'brooding meditation'.[1] This seems to be an accepted, rather comfortable point of view, as the subject covers the invention of a 'black-box'-type too. But the invention, development and the adaption of this gyro instrument in a complex technological and social system was not achieved on the basis of a 'single-handed' venture.

If emerging technologies are not only scientific, but also involve social or cultural requirements,[2] then communication along the networks of knowledge[3] between inventor, mechanic and mathematician, the code of patent lawyers and financiers and – last but not least – navigation officers and the red tape of a navy must play an influential role. I would thus like to sketch out the subject of invention as communication and present the inventor as a navigator, someone who leads his crew through all currents, shallows and drifts and, while keeping ahead of other competitors, arrives at some still uncertain location.

One of the frequently cited patterns of technological change, the 'presumptive anomaly',[4] the predictable failure of a traditional device, surely does not apply here. The effect of the growing use of iron in shipbuilding on the function of the magnetic compass was easy to foresee, and it did lead to concern in the navies; however, this was not enough for a technological revolution, rather an attempt to start improving the up-to-then neglected magnetic compass.[5] Moreover, the development and adaption of steam and steel, originally transferred to naval use from landbased technologies, widened the gap to other components essential to navigation. The 'reverse salients'[6] of the technological system grew, not only in the performance of the magnetic compass but also in the rather conservative opinion of naval authorities about this critical development, relying only upon armour, guns and speed.

Likewise, the theoretical basis necessary to support the surveying of these unknown fields of applied mechanics was not very well developed. The interaction between the theory of mechanics and the practice of craftsmanship, with its tacit knowledge in naval technology, was rather limited, when we recall Newton's or Euler's influence, for example. King Frederick II of Prussia, for whom Euler had served, mocked the abstruse derivations of Euler, after he had experienced the loss of some of his manuscripts: 'a ship, carrying his XZ' and

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KK's was shipwrecked; everything was lost, such a pity, because he could have filled six volumes with his treatises, cryptographs from A to Z; I assume Europe will deplore this tragic loss and miss the pleasure of its lecture'.[7]

It was for these reasons that gyro technology developed not because of, but rather independently of – or even, as Elmer Sperry put it – in spite of, higher mathematics, but through the convincing art of the experimentist and demonstrator. There was no real theory of discovery, but just dead reckoning, followed step by step and using the trial and error method.

The gyro first gained popularity by demonstration models such as the 'machine, to demonstrate the laws of rotation of the Earth' developed by a German, Johann v. Bohnenberger,[8] in 1817 and the gyroscope of a Frenchman, Léon Foucault,[9] in 1852. Using at first a simple device, a pendulum not much different from a sounding-lead, Foucault succeeded in demonstrating the revolution of the globe. He also stated that an undisturbed gyro would remain in a fixed position in space; and also formulated his tendency of parallelism, in which he stated that a revolving body, mounted horizontally, would have the tendency to align itself parallel to the Earth's axis, and thus point true north. The concept of the gyrocompass was given, but only for solid ground. The severe difficulty, however (and this only became apparent during the following 70 years), was to transfer this concept from solid ground to aboard ship and to differentiate now between the Earth's rotation and the ship's movement, rolling and pitching.

The idea of 'simply' substituting the magnetic needle by the axis of a revolving wheel, thus adapting Foucault's principle to the magnetic compass system, and mounting it like an actual liquid compass,[10] was developed by the Dutchman Leendert Janse and appeared in patents in Great Britain,[11] communicated by the Dutchman, Marinus Gerardus van den Bos and later in Germany,[12] here patented for Marinus van den Bos and Barend Janse.[13] This kind of suspension was also mentioned in a paper by William Thomson, later Lord Kelvin, who possibly knew about the British patent. Thomson had patented his own improved magnetic compass before and surely assumed the role of a look-out regarding developments in this field.[14]

A yachtsman himself, Thomson was one of the few personalities who were able to navigate through complex mathematics and, at the same time, were aware of the practical needs. Maybe for this reason, Thomson, though experienced with gyros, kept to conservative improvements to the traditional magnetic compass, which were finally accepted and achieved profits for some 20 years, despite the initial scepticism of the Royal Navy. His contemporary opponent, Werner Siemens, however, expected to make a quick crossing to the new prospects of navigation instruments in buying and exploiting the patent of the van den Bos. But Siemens soon ran aground with this device, and no logs or reports of this failure were saved except a few lines to his brother and the one instrument which survives in the Deutsches Museum.[15]

The use of a small, but fast and continuously revolving gyrowheel, demanded the application of electricity and the electric motor, a technology then only

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in its infancy aboard ships. The blend of two rather complex innovations proved to be too risky for a reliable navigation instrument. The direction-maintaining power of the gyroscope was used only in the unmanned torpedo, for a run of some minutes, and on short one-way trips with no return.[16]

Yet the needs of a new era of vessels and vehicles were obvious. Submarines and aeroplanes which moved in three dimensions and stabilised platforms on ships all needed new directive steering devices beyond the capabilities of a human helmsmen. Hiram Maxim and Henry Bessemer are among the famous inventors who ventured into gyroscopic controls, but without success. In fact, in the era of 'flywheeliosity',[17] nearly every mechanised vehicle contained flywheels which acted as gyros. Revolving paddlewheels had shown an influence on the stability of ships – an effect that was subsequently multiplied by the naval architect Otto Schlick with gyro-stabilisation of ships, a popular and large-scale demonstration of this new technology.[18]

Around the turn of the century, the 'gyro culture'[19] also supported by gyro-toys thus acted as a beacon and became popular enough to attract other private inventors or professionals like physicians. This was the time of enthusiasts who dared to cross an ocean in a dinghy. Two of these were Germans, Narziß Ach and Hermann Anschütz-Kaempfe. Ach had graduated both in medical science and psychology and was engaged in the new field of psychotechnique. Experiments with organs responsible for equilibrium in frogs had resulted in a patent in ship-stabilisation. Anschütz-Kaempfe had studied some physiology and after some private polar cruises, around 1902 thought it would be a good idea to reach the North Pole in a submarine equipped with a gyroscope, just for scientific purposes.[20] One can imagine the disrespect of the Imperial German Navy for this project of a private gentleman, as the Navy then rejected even the development of its own U-boats. Working on a gyroscope, it took Anschütz-Kaempfe years of socialising, lobbying and parading in the showrooms of 'navalism' to find recognition. In 1904, he presented his first gyroscope to representatives of the Imperial Navy,[21] but it was rejected, just as in 1905 a modified version demonstrated to the Royal Navy was regarded as too delicate in construction for practical purposes.[22]

Inventing an instrument in those days meant recruiting a crew of at least three; besides the inventor and 'skipper', a good mechanic and a patent-attorney; if possible, a patient sponsor and a 'communications-officer' to the Navy. Patent laws were the rules of this race among the numerous inventors, according to which no one was supposed to make the same technical-tactical move as the leading team had done. Ach cooperated with the firm of Hartmann and Braun in Frankfurt.[23] The instruments of Hartmann and Braun, which were supposed to keep the azimuth, and were not north-seeking, were tested but not acquired by the Imperial Navy. A single instrument is now kept in the Deutsches Museum.

When the first Anschütz prototype was also not accepted by the Imperial Navy, he ran short of money and asked the Siemens Company to take over. However Siemens, which in the meantime had invested in the conventional

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system of transmitting magnetic compasses,[24] decided to overhaul their old patent instead and to make more soundings regarding the feasibility of the principle. A member of the research staff, Oskar Martienssen, a graduated physicist well equipped with Eulerian mechanics, reported after new trials that a gyrocompass could not be used in ships, as the immense inertia of the fast rotating wheel produced a long period of oscillation which made it impractical aboard ships turning at the same rate.[25] Anschütz-Kaempfe was upset, but being given new directions to proceed to the 'impossible', found an appropriate damping method for these oscillations. In 1908 the Anschütz Company finally succeeded in crossing the finish line and sold a prototype to the Imperial Navy; 'there was no second', Ach and Hartmann and Braun were well out of competition, Siemens had given up. From 1910, the Anschütz instrument was also built and installed under licence by the British company of Elliott Brothers.

In the Anschütz gyrocompass, the spinning axis of the gyro, driven at 20 000 revolutions per minute, was arranged but not fixed to the horizontal plane in a case floating in mercury, giving freedom of movement about the horizontal and vertical axis. As means to control its position relative to the Earth, the gyro was suspended slightly pendulously, thus harnessed by gravity so that its axis was brought into line with the north–south axis of the Earth by forces of precession. The subsequent oscillations about this direction, due to the gyroscopic inertia, were dampened by special devices. The pendulous suspension was a source of errors due to accelerations of the ship, known as ballistic deflection. Max Schuler, a graduate engineer who had joined Anschütz, found that a pendulous device with a period of 84 minutes – equal to a pendulum of the Earth's radius – automatically corrected for the disturbing influence of ship accelerations. This essential effect, later called Schuler tuning, was to become fundamental to gyro-navigation systems.

After the first gyrocompasses of the Anschütz Company had proved practicable, the American inventor Elmer Sperry entered the competition.[26] Sperry realised the market for gyroscopes for marine purposes[27] and, well aware of the patent situation, decided to improve upon the existing designs. Based on the networks of the 'community' which had built up in Europe, Sperry visited Germany and Anschütz in 1909, and later England and the inventor Sidney Brown. In 1911 the Sperry Gyroscope Company presented its first gyrocompass. Sperry found the American Navy better prepared and structured for new technology, quite unlike Anschütz-Kaempfe's dealings with the Imperial Navy before. Graduate officers such as the Admirals David W. Taylor and Bradley Fiske turned out to be valuable pilots when approaching the subject of the introduction of new technologies into the navy.

The two models of gyrocompasses both had to compete in the offings of practical service, acceptance and marketing. During sea trials and later tests conducted for the British Navy, by Professor James Henderson, Physicist of the British Admiralty, both types of gyrocompasses showed rolling or quadrantal errors. These deviations were caused if the ship, rolling in a seaway, took courses between the cardinal points. Both designs were improved with additional gyros.

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In 1912, the Anschütz Tri-Gyro-compass appeared; Sperry, with suggestions received from Henderson, introduced a single additional auxiliary gyro two years later.[28]

Due to the similarities in the design of these gyrocompasses, a great deal of energy was mobilised in priority claims and patent infringements. In 1914, the Anschütz Company started patent litigation against the Sperry Company; Sperry argued that the Anschütz basic patent showed no substantial progress compared with the 'classic' patent of van den Bos. The German court asked Albert Einstein, physicist and former Swiss patent expert, to assess the case, and after two opinions of Einstein, Sperry finally lost.[29]

Clearly then, the shaping of technological systems was more and more influenced within political borders. As Sperry continued deliveries to Great Britain, the Englishman Sidney Brown together with Professor John Perry designed and patented a gyro compass in 1916 that was supposed to compete with the Sperry. It achieved a nearly frictionless vertical axis on a pulsating cushion of oil, and introduced a liquid level control using interconnected boxes to the single gyro, which proved to be unaffected by the motion of the ship in a seaway. Then, a similar device, called 'mercury ballistic', was used to improve the existing Sperry compasses in service. Again, the close interaction of Sperry and Brown led to arguments about priority rights. In 1927 the British Admiralty set up a Committee to investigate the relation between the Sperry compass and the Brown compass with reference to the level control. The Committee found that Brown and Henderson had devised the original concept.[30]

The First World War had provided the testing ground for the gyrocompass, revealing a number of defects which had to be resolved. Anschütz-Kaempfe sought to mount the gyro system in a frictionless spherical case surrounding the gyros which enabled it to float without contact with the case. Einstein, who had become friends with Anschütz-Kaempfe, and found his factory in Kiel a good retreat for his own research and an occasional sailing trip, suggested a solution for centring the floating sphere with a magnetic coil[31] and backed Anschütz-Kaempfe with more opinions in numerous patent infringements.

In the post-war period, the demand for gyrocompasses dropped, and their manufacturers tried to transfer applications, previously developed for automatic steering for unmanned boats during the war, for the use in the merchant navys. This resulted in ships' automatic pilots. Thus inventors put a new, and rather pale and docile crew-member on the payroll. The automatic pilot replaced the helmsman and mechanised the art of navigation. And, whether nick-named 'Eiserner Gustav' or 'Metal Mike', he 'didn't drink, smoke or kick about working overtime…'.[32]

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[6] T. P. Hughes.

[7] Letter from Friedrich II to Jean d'Alembert, 26.7.1766; cit.: Hankins, T. L., Jean d'Alembert. *Science and the Enlightenment*. Oxford 1970, p. 62.

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[10] The liquid compass was used since 1841 by the Royal Navy.

[11] GB Patent No 8394, 29.5.1884: 'Improvements in the Mariners' Compass for use at sea and elsewhere; communicated by Marinus Gerardus Vanden Bos, of Leyden.' As the invention was claimed by Sydney Pitt of Sutton, this invention is mentioned in later communications in Great Britain as the 'Pitt-machine'.

[12] DRP No. 34513, 19.4.1885.: 'Neuerung an Schiffscompassen, Marinus Gerardus van den Bos in Leyden und Barend Janse im Haag.' Due to this patent, this invention is in Germany generally known and communicated as the 'van den Bos–Kreisel'. See, for example, Albert Einstein's opinion of 6.2.1915, in *Einstein, Anschütz und der Kieler Kreiselkompass* (D. Lohmeier and B. Schell, eds.) p. 229. Heide, 1992.

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[31] Einstein received shares due to his contribution for DRP 394667, which he demanded until 1940. Lohmeier, 58.

[32] Hughes, 1971, 279.

KEY WORDS

1. History. 2. Instruments. 3. Sea.

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