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Prototyping Worlds
Emergent Technologies in the Aerial Age

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Emergent Technologies in the Aerial Age

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Abstract

This paper takes its point of departure in the years leading up to, and shortly after, the outbreak of World War One; a period that saw the emergence of Europe's first aeroplanes. It argues that the production of new aerial objects required not just imaginative leaps in technology, but also the making of possible futures into which such technologies could fit. In order to elaborate this argument, the paper engages with the life and work of J.C.H Ellehammer, the Danish inventor-entrepreneur who claimed the honour of being the first man to fly in Europe in 1906. Through an examination of Ellehammer's heterogeneous activities and practices, I argue that his initial aerial prototypes are 'not-quite-yet-flying machines.' As technologies of anticipation they model, or rehearse, a version of the future through which such machines could become more acceptable to a sceptical public and find their place within a broader national discourse on flying. This is based upon a particular reading of the prototype as both an epistemic object and an epistemic culture, and upon a rendering of prototyping as an analytic that approaches the craft and agency of objects in particular ways.

Keywords: prototyping, technology, innovation, anticipation, STS, aviation

Introduction

On a high summer day in August, four years prior to the close of the nineteenth century, Otto Lilienthal's glider was caught by a billowing gust of upward moving wind. Despite the culmination of 2,000 prior glides and a reputation for extraordinary athleticism, the renowned airman lost his life as his glider stalled, rolled right and pitched fifty feet downwards into the mossy grass verge below (Hallion 2003: 161). Lilienthal's gliding apparatus, the most sophisticated of its time, was the culmination of many centuries of aerial dreaming, tinkering, experimenting, and ultimately, failing, and his death was a bitter testimony to one of the century's as of yet unresolved problems; powered, controlled and sustainable flight. However, within the space of twenty years the great European powers were producing in excess of 10,000 such flight machines every month (ibid 2003: 378) in an attempt to leverage military dominance over the skies and lives of the citizens of Western Europe.

This paper takes its point of departure in those intervening years between the Lilienthal glider and the sleek war machines of World War One. Although flying machines of a kind had been around for several centuries, man's eternal longing for sustained powered flight was realized within a rather circumscribed span of time that very few could have foreseen.[1] What followed was the emergence of multiple figurations of aerial objects, not just glider and ornithopter inspired machines mimicking bird and bat movements, but locomotive hopping steam engines, nascent boat-house aircraft carriers, as well as hybrid man-plane formations and plane-helicopter cross breeds (see figure 1).

[1] As a type of testimony to this statement take the Wright brothers' categorical opinion, after they themselves had flown, that flight did not have the potential to develop into a transport system because flying machines would never be able to sustain themselves over large bodies of water (Crouch: 2003).

Figure 1: An artist's rendering of Flying Machines in the Danish newspaper, Politiken. Accessed in the Ellehammer Archives at the Danish Museum of Science and Technology.

Such emergent flying technologies did not occur in isolation, but were a part of the great age of invention, a time in which the labours of the industrial revolution began to bear fruit, and which has been characterized by the more dominant modes of historiography as consisting of promethean men breaking through the last bastions of nature's laws, thrusting their inevitable inventive results upon the world as a consequence (Hughes 2004). Such a characterization is not the tack that this article will take. Instead, it will argue that the emergence of variously figured flying technologies could only be accomplished through sets of practices that were both highly imaginative, yet at the same time mundanely practical, and which, importantly, involved new modes of organizing. Said another way; the production of new aerial objects required not just imaginative leaps in technology, but the making of possible futures into which such technologies could fit. In order to elaborate this argument, I will engage with the life and work of J.C.H Ellehammer, the Danish inventor-entrepreneur who claimed for himself the honour of being the first man to fly in Europe in 1906. Through an examination of the activities and practices in the period up to and beyond his engagement with, as he put it, '*the problem of flight*' (Ellehammer 1931), I will argue that Ellehammer was involved in the production of flight machine prototypes that were not just technological artefacts, they were, at the same time, technologies of anticipation - receptacles for rehearsing a version of the future through which such technologies could find their place. To accomplish this aim, the paper will be laid out in two sections. The first will specify in more detail the 'problem of flight' and the type of relations that such a problematization characterizes. In particular, I will focus on several relational components, namely; the gifting of the island of Lindholm to Ellehammer which was essential in the emergence of his first flying machine prototype, the construction of a completely new, yet elaborate, financial innovation called the patentbank, and finally, how these two latter components were enfolded into the emergence of a receptive public. After his proclamation that he had 'resolved' the 'problem of flight,' Ellehammer immediately proceeded to re-orient the problem by changing its very definition. This section of the article will examine Ellehammer's efforts to reconfigure the '*problem of flight*' through the production of an alternate prototype; a hybrid plane-copter. It is important to note that in the years leading up to World War 1, what constitutes 'flight' is still an open question. Defining a solution to a problem that they themselves had configured was a way for the aerial men of the day to mobilise enough support to continue on with their flying adventures. At this moment in history, 'flight' was still very much in-the-making.

The Dream of Flight

One could argue that the dream of flight has had a special place in the imagination, stories and practices of humans for many centuries. From the first kite flyers in China, circa 600bc, to the tower jumpers of the middle ages (those who leapt out of monastic towers donning feathered wings or utilizing proto-parachutes), right up to those, who, like Otto Lilienthal, paid for their dreams with their lives. The historical record is replete with flight-based events and stories, in which the quasi-magical zone between heaven and earth was the inspirational setting for myths, religion, art and literature alike. The invisible air

has always been a place of both power and awe, insubstantial yet eliciting effects, having long been associated with both the spiritual and the supernatural. Flight has come to signify more-than-human status across many cultures, as Gods, kings, shamans, prophets, saints, sages and witches, have all demonstrated their ambiguous power by flying through this liminal space (Singer 2003). The winged inhabitants of the air have been attributed a special place in the stories of many. In Christian iconography doves carry messages between heaven and earth, symbolizing peace, while for the Assyrians and the Greeks the milky white creature was a sign of fertility. At Delphi, ravens symbolized wisdom and science, in the north blind Odin depended on Huginn and Muninn for his vision and knowledge of the world, while among the Alaskan Inuit, the same bird once again is famed for its trickster techniques. Blackbirds have been symbols of death and retreat, while eagles connoted majesty and divinity for both Romans and Americans alike, and much more besides (ibid 2003: 23).

It is in the post Newtonian age that flight begins to be approached and apprehended in a different manner, where the mechanized worldview, one in which, '*each substantial thing is thus conceived as complete in itself, without reference to any other substantial thing*' (Whitehead 1967: 169), begins to unfold and, one could argue, where the mythologizing tendencies of former times begin to play themselves out in a different register, finding a mode of expression in the predilection for attributing almost mythical status to the promethean inventor of new technologies. In the time frame with which this paper concerns itself, narratives of inventor and invention abound, particularly so in historical accounts of flight as told through the optics of the putative inventors of the airplane, the Wright brothers. Aviation historian Richard Hallion sums up these proclivities very well in one of his many catch-all phrases, '*Why were the Wrights - and hence Americans – victorious in inventing the first successful airplane?*' (2003: 381).

[2] As we shall also see later on this is one of the many interesting parallels that can be drawn between the Wrights and Ellehammer.

Although the Wrights undoubtedly played a hugely significant role in the aerial age, even a cursory look at their activities brings Hallion's definition of invention into sharp relief. Only after reading the works of Otto Lilienthal via the work of Octave Chanute, himself a French immigrant to America, did the Wrights tackle flying as an issue of controllability.[2] Lilienthal was almost entirely indebted to George Cayley, the man who first brought what would turn out to be the essential components of aerodynamics (lift and thrust) to bear on flight mechanics, but who himself was indebted to Newton's laws of motion, as well as the entire science of mechanics and fluid dynamics (Crouch 2003). One could continue on ad infinitum but suffice to say that the actors who intercede in flight are so numerous and so entangled with each other that at the end of the process it is nigh on impossible to know to whom the paternity of the results should be attributed. As Akrich et al nicely put it,

> "in the heat of action, there is no architect but several, no decision maker but a multitude, no single plan but ten or twenty which confront one another" (2002a: 192).

This paper does not travel through the vast bulk of literature on invention and innovation, but instead draws upon an STS inspired approach to the emergence of the new, typified by the citation above from Akrich, Latour, and Callon (2002a; Akrich, et al. 2002b). What this approach suggests is that any attempt to gain access to the new is less a process of mastering, or re-mastering, the current features of the world than of making new worlds. The particular path this article takes is via the concept of the prototype.[3] In *Prototyping Cultures, Art, Science, and Politics in Beta,* Alberto Corsín Jiménez *(*2017*)* suggests that the prototype works as a descriptor for both epistemic objects

[3] Etymologically the word prototype breaks down as *proto* (original/first/primitive) and *type* (form/impression).

and modes of making such objects. As epistemic object a *prototype* is a beta, or work-in-progress version of something; an entity in-the-making.

At the same time, *prototyping* is a provisional and experimental mode of practice that offers us a way of thinking about the status of 'things-that-are-not-quite-objects-yet.' These 'not-quite-yets,' Corsín Jiménez argues, are prefigurations of things and of sociality, as they model the possibility of what is to come (ibid:3). What I argue in this paper is that Ellehammer's initial aerial prototypes are 'not-quite-yet-flying machines.' As technologies of anticipation they model, or rehearse, a version of the future through which such machines could become more acceptable to a sceptical public and find their place within a broader national discourse on flying. In contrast to this, Ellehammer's later prototypes become overly reliant on specific technologies of ownership as his patenting struggles begin to affect they ways in which the aerial community of the day respond to his flight machines. Taking up Corsín Jiménez's suggestion that 'prototyping is what happens to social relationships when one approaches the craft and agency of objects in particular ways' (ibid), the paper lays specific emphasis upon Ellehammer's heterogeneous practices as he creates new modes of organizing and builds new institutions as a means to continue his flying adventures.

Problem Solving as Flight Event

Jacob Christian Hansen-Ellehammer (1871-1946) grew up on the small island of Lolland Falster,[4] where as a young child he constructed and played with large kites made from the remnant canvass of his father's windmill. This formative period of play is one which he acknowledges as being that without which '*I never would have managed to construct a flying machine'* (Ellehammer 1931 :16).[5] After a teenage apprenticeship at a watchmakers, Ellehammer moved to Copenhagen where he worked at a 'mechanical establishment' dabbling with electrical engineering and gaining experience installing the first telephones and electric street lamps in Copenhagen (Kornerup 2007). At twenty-seven years of age he quit his paid employment and set up his own workshop on Istedgade in Copenhagen, where, aware of the great inventions of his time, he proceeded to produce a variety of novel apparatuses.[6] Despite such a broad palette of devices, it was the flying machine that he returned to intermittently over the course of his life from his mid-twenties until his death in 1946. There had been and continued to be many forms of aerial engagement up to that point, in particular lighter-than-air machines, including balloons, dirigibles and gliders. However, these machines were constantly prone to the vicissitudes of the weather and as such found it difficult to exercise any form of control over their ultimate destination. It was the heavier-than-air machines around which the problem of flight crystallized; the dream of attaining manned-powered-sustained-controlled flight. From early on in his autobiographical account of flying Ellehammer's language is punctuated with, and highly orientated around, finding and resolving problems, none more pressing for him than what he termed '*the problem of flight '*(Ellehammer 1931 :35). This specific term reoccurs multiple times, as does his general reference to flight as a 'problem' (Ellehammer 1931 :35). I want to bring an ethnographic sensitivity to Ellehammer's own mode of rendering these events, not by taking his autobiography literally, but by taking seriously (Holbraad and Pedersen 2017) his near obsession with flight as a 'problem'. Alternatively said; this paper treats 'problems' and their 'resolutions' as ethnographic points of departure, anchored in a reading of Ellehammer's own characterization of the events of his time. To help me do this, I want to draw upon a particular concept from the

[4] From three years of age he resided at Storholmen, Vålse Vig, a small inlet on Northern Falster, which lies just south of Zealand, one of Denmark's five principle regions.

[5] All translations from Danish are the authors.

[6] Including but not limited to many pay-as-you-go devices, such as a film machine, a phonograph, a beer machine, a cigarette machine and an x-ray machine. In addition, and more substantively, he designed and produced a radial (star) motor and the first motorbike in Denmark.

work of Gilles Deleuze and Félix Guattari. In a *Thousand Plateaus (1988)* Deleuze and Guattari introduce a notion called 'the untimely;' a way of thinking and acting that pushes at the limits of what is known. Rather than focusing on the process of how-to-be creative or eureka moments of creating the new, Deleuze and Guattari emphasize thinking and working at problems in ways that create new modes of conceptualizing and responding to them (ibid :3) What Deleuze and Guattari approach from a purely theoretical perspective, Ellehammer approaches heterogeneously; developing not just conceptual, but also practical tools for contending with problems. Approaching 'problems' and their 'resolutions' in an untimely manner means, for Ellehammer, both developing new modes of organizing and devising new institutional arrangements in response to such 'problems.' What becomes clear from the available material on Ellehammer's life and work [7] is that such 'heterogeneous engineering' (Law 2011) also extends to his very use of the terms 'problem' and 'resolution.' Both are temporary constructs that facilitate him in navigating through the complex socio-technical, political, and cultural terrain of his time. 'Engineering' these terms to fit the public discourse on flying at any one given moment enables Ellehammer to mobilise an infrastructure of support for his flying endeavours. At the same time, re-defining the meaning of these terms at other, more opportune, moments, facilitates him in steering the opinion of a sceptical flying public. Attaining manned-powered-sustained-controlled flight is, in this sense then, not a eureka moment, but an event; '*a task to be performed or a problem to be solved*' (Deleuze, et al. 2004:264).

[7] The data for this article comes from several sources. Firstly, a review of the Ellehammer archives held at the Danish Museum for Science and Technology. Additionally, reliance on secondary historical accounts from Danish historians, but particularly the work of Louise Karlskov Skyggebjerg. Finally, an ethnographic analysis of Ellehammer's autobiography.

Prototyping Patents, Places, and Publics

Right from the start of his workshop career in Copenhagen, Ellehammer seemed to move dexterously and fluidly between the varying roles that were demanded of him in his pursuit of the resolution to the problem of flight. Albeit more in the spirit of a bricoleur (Lévi-Strauss 1968) than a specialist, he moved from empirical engineer, constantly tinkering, building and testing his machines, to an employer running a small workshop employing several staff, to a financial entrepreneur raising capital and constructing new financial entities, to finally a type of public relations maverick chartering the choppy waters of flying scepticism that the general public and the media of the day were inclined towards. On September 12th 1906 Ellehammer wrote the following to the local newspaper in Falster, '*I can now say, that I consider the problem (of flight) resolved*' (Karlskov Skyggebjerg 2006 :52),[8] an intriguing statement considering that his flight machine only covered a distance of 45 meters at an altitude of 50 cm. Additionally, the machine was tethered to a steel pole by a wire as it flew in a circular direction on the small island of Lindholm. While such a statement has been labelled as self-aggrandizing posturing by some commentators in Denmark (Mygdal - Meyer 2001), and defenced by others, I would like to offer an alternative reading based upon an ethnographic frame that locates Ellehammer's actions within a two phase approach to the 'problem of flight.' The first phase, which mainly focuses on his time up to and including the self-proclaimed '*first successful flight in Europe'*(Ellehammer 1931) on the island of Lindholm, was driven by a need to finance, produce and test a flight machine which would have sufficient potential to placate investors, both present and future, secure ownership rights and be acknowledged in the eyes of a sceptical media and public as an activity worthy

[8] This citation appeared in Møns Folkeblad on September 13th 1906, one day after Ellehammer's self-accredited flight.

of more than scoundrels and madmen. Once this phase was accomplished, Ellehammer moved onto a re-orientation of the 'problem of flight,' and set about producing a new flight machine. An analysis of both of these problem-resolution phases, or events, captures the particular ways through which Ellehammer not only builds prototypes, but prototypes worlds into which such 'not-quite-objects' can fit.

Like most inventor-entrepreneurs of his time, trying to raise sufficient capital was of paramount importance for Ellehammer.[9] The activities of the workshop in Copenhagen met on-going working capital requirements, but were insufficient for any larger capital outlay. Even his sale of 227 own branded Elleham Motorbikes (Karlskov Skyggebjerg 2006 :38), was not enough to finance his greater ambition of constructing a flying machine. Along with a friend and business partner, Viggo Knuth, Ellehammer became involved in the setting up of a novel hybrid institution called a *patentbank*. The first patent laws were enacted in Denmark in 1894 (ibid 2006: 35) and Ellehammer took advantage of such novel technologies of ownership by combining investment possibilities and ownership rights within one institution.[10] Leveraging Knuth's connections to the nobility of the day, the patentbank operated as an investment bank, manufacturing company, and patent broker all rolled into one. The more familiar set up at that time was either to develop and sell patents to third parties or set up a business that would commercialize the patents into saleable commodities. The hybrid institution however:

> "gathered together investment risk under one roof in connection with a number of patents. This meant that the individual investor did not have to sink his money into one invention only, but that the risk would be spread across a large number of patents" (Bang 2007 :22).[11]

In many ways Ellehammer's patentbank was also a type of patent lab, which, funded by investors, worked on a portfolio of patents simultaneously. For his troubles, Ellehammer received a 6,000 kroner a year salary from the patentbank as technical director, which whilst contractually a full time position was very liberally interpreted by him (ibid 2007 : 24). At the same time, he raised capital for himself by selling some of his own patents to the patentbank for development - such as the Elleham motorbike, as well as a share in his franking machine and flight machine patents. However, despite having a part share in the flight machine, it seems that the patentbank only ever paid out money to the Lindholm project, the expenses of which dominated the company's accounting records (amounting to 47,000 kronur in total) (Bang 2007: 31) Although the patentbank received a very sceptical reception in the financial press of the day for its '*highly unusual and peculiar mixture of services and structure'* (ibid 2007 :26), as did Ellehammer himself,[12] the institution did provide the necessary resources to carry out the flight initiative on the island of Lindholm. It was on this '*flyers paradise'* (Ellehammer 1931 :65) that the first flight machine prototype emerged.

[9] See Tom Hughes, *American Genesis* (2004).
[10] Although my knowledge on the subject is not exhaustive, I cannot find evidence to suggest that such an institution had been developed before or since. Although the dizzying array of financial instruments of today's finance capitalism no doubt involves far greater levels of complexity and hybridity, such developments can mostly be charted from the 1970's forward.

[11] The company's articles of association stated that the motive for the establishment of the patentbank was '*the lack of a bank institute with the important mission of providing financial and technical assistance for patent development and the exploitation and sale of patent protected inventions both at home and abroad'* (Bang 2007: 22).
[12] Knuth's sister is quoted in her diaries as saying ''*Ellehammer was a sneaky peasant. After he sold an invention, he always 'came up with' an extra little enhancement or two for the very same thing, which he then immediately demanded a considerable extra amount for*" (Ellehammer: 1931).

Lindholm, a tiny Island north of Lolland-Falster, was temporarily gifted to Ellehammer by Knuth's uncle, Count Knuth Knuthenborg. Using the finances from both the patentbank and other, unverified sources,[13] Ellehammer worked with both his cousin and brother in an attempt to achieve the first heavier-than-air flight in Europe. In his autobiography Ellehammer characterises the attempt in the following manner;

> "One thing is to have a test machine finished in the workshop; it's a whole different thing to actually go out and do the test. I knew of people's curiosity, disbelief and impatience and I knew that if I were to test my machine close to the city I would become a laughing stock. After all I didn't dare to hope that my machine would rise up and buzz around amongst the birds straight away. Not a single human being would believe in the possibility of solving the task and therefore it was all about finding a fitting place for such crazy attempts, a lonely place far away from both a sceptical public and press" (*ibid 1931:44*).

What this statement brings out is not only Ellehammer's need for a peaceful place to work and test his flight machine, but more importantly, it binds his desire to solve the problem of flight with an acute awareness of the importance of a receptive public. Getting a patentable flight machine into the air that would convince a sceptical public was Ellehammer's primary focus during this first flight event (problem-resolution phase) on Lindholm.

While it is difficult to locate the paternity of the aeroplane within its long-entangled mesh of flight interactions, there was undoubtedly some significant developments in flight understanding and practice that narrowed down the range of possible resolutions to the problem, in particular the application of fluid dynamics to aeronautics. Interestingly, and unlike many of his fellow Europeans, Ellehammer's area of concentration paralleled that of the Wright brothers by focusing on aerial control and stability (or equilibrium). To achieve this aim, Ellehammer and his assistants devised and patented an automatic pendulum stabilization system, an interesting human-machine hybrid that allowed for vertical flight control by adopting a configuration which shifted the weight of the pilot back and forth, from nose to tail, in order to compensate for either a vertical incline or decline.[14] However, given that Lindholm was so small it was necessary to build a 1 km circular concrete runway[15] that would allow enough speed to be gained to enable take off. A further consequence of this was that the machine had to be tethered by a wire to a pole at the centre of the runway in order to avoid the machine dumping into the nearby sea. Ellehammer was hopeful that recent developments in wing technology would enable him to design a wing structure giving sufficient lift

[13] Bell (2006) gives details of another Flight machine company that was set up in Ellehammer's name, and which puzzlingly has accounting entries that show a receipt of money from the patentbank. However, the details of the transaction are not clear enough to come to any particular conclusion.

[14] While different to that of the Wright brothers, Ellehammer's solution moved very much in the same direction. The Wrights, while also using the pilot's body as a tool for controlling the flight machine's vertical stability, made the additional move of accounting for horizontal control with a technique known as 'wing-warping.' This technique allowed the pilot, lying in a prone position, to literally warp the wing's shape via rotations of the hip and leg and thereby achieve the necessary wing lift to effectively turn on the horizontal axis.

[15] An apparent first of its kind, the concrete circular runway was built by Ellehammer's cousin Lars (Karlskov Skyggebjerg 2006: 55). In addition, several other 'firsts' were achieved such as the deployment of fixed wheels to the undercarriage and a propeller at the front of the machine.

to get the machine off the ground. He was also confident that the radial motor from his Elleham motorbike could be modified to attain the power to weight ratio necessary to sustain a flight upon take off.[16] Believing that he had successfully resolved the issues of take-off and power, Ellehammer focused almost exclusively on the final issue of control via his pendulum aerial stabilization system. With the requisite financing from the patentbank and the process of patenting the pendulum system under way, Ellehammer made many attempts 'to fly' on Lindholm between November 1905 and September 1906. Within this problem-resolution phase many flight machines emerged, all adopting slightly different configurations, but it was the one that incorporated the pendulum system stabilization apparatus that finally took off on September 12th 1906. The attainment of an altitude of 50 centimeters in such a machine is what ultimately enabled Ellehammer to declare to the press of the day that he had finally resolved the '*problem of flight*' (see figure 2).

Figure 2: Lindholm Prototype. Picture from the archives of the Danish Museum of Science and Technology.

[16] Although retrospective analyses suggest that Ellehammer's experiences with kites led to the construction of wings that were far too reliant on wind speed, rather than being directed by the lift mechanisms of George Cayley.

Although such a declaration could seem slightly brazen from a contemporary perspective, if not a little absurd, I would like to postulate that while such a prototype allowed Ellehammer to technically claim a resolution to the problem of flight, it did a lot more than just that. As mentioned earlier, Ellehammer was acutely aware of the public's incredulity towards the idea that man and machine could join in aerial union for any prolonged period of time. Local newspapers and the national press displayed an almost open hostility in their depiction of his flying attempts, lambasting him with satirical jabs and statements such as 'the Fyn Reaper'[17], in addition to calling his flying machine 'The Lawnmower' (see figure 3).

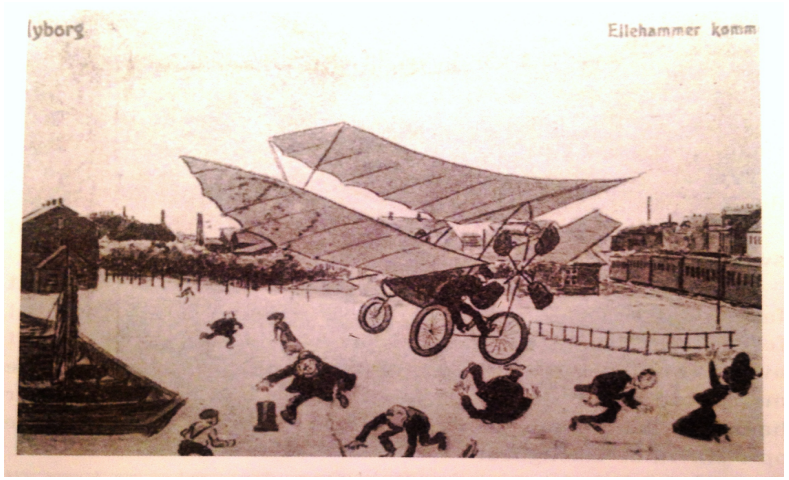

Figure 3: Satirical Newspaper Cartoons. Picture from the archives of the Danish Museum of Science and Technology.

[17] Fyn, where Ellehammer grew up, is the middle island of Denmark's three large islands.

One famous comment by an English professor was quoted in the media as saying:

> "Dear Professor Ellehammer, you need have no fear of falling from the sky as it is most likely that you will never get up there in the first place" (Ellehammer 1931:51).[18]

The Lindholm prototype allowed Ellehammer to claim, with a degree of credulity, that he had resolved the problem of flight and as such was the first European to fly. Many other aviators were, at that time, in the throes of attempting to be accredited with the same honour. While there had been rumours that the Wright brothers had flown in 1903 there was little information about the type of flying machine that they had designed, or, for that matter, what kind of 'flight' they had achieved. The latter decades of the nineteenth century had seen a series of powered take-offs, leaps and glides, along with some simple powered and sustained flights (although without 'proper' flight control) in heavier-than-air machines (Gibbs-Smith 1965 :4) which, for the most part, only functioned with some form of lift, thrust or stabilization assistance - not wholly unlike Ellehammer's wire tethered machine. However, it was Santos Dumont that ultimately took official credit for his 1906 effort in Paris, flying for 21 seconds and covering 220 meters. This first flight event (problem-resolution phase) from which the Lindholm prototype emerged, arranged patents, places, and publics within a configuration that was 'good enough' to work as a temporary resolution to the problem of flight, as specified by Ellehammer. The new, and unheard of, patent bank was an innovative organizational form that produced sufficient financing to enable the Lindholm experiments to take place. At the same time, the small islands absurd geographical restrictions as a test flight location became

[18] A variety show running in Copenhagen at the time had an amusing one liner that said, *'What horrible times we are living in, meat prices are rising as are bacon prices, the only thing that isn't rising, is Ellehammer!* (Ellehammer 1931: 58).

materially embedded within the definition of what constituted 'flight.' Within Denmark the Lindholm prototype was an important part of a wave of developments that captured the imagination of a public that had, up to that point, ridiculed the notion of flying. One of its effects was to displace an image of flying as the terrain of errant, if not slightly off kilter, individuals, to one of a collective national enterprise. In particular, it provided a mechanism for rallying around a national project at a time when Germany, just prior to World War One, was beginning to appear as an aggressive, technologically sophisticated, neighbour. This ability to create a new and receptive flight public, or to bring new flight publics into being (Marres 2005), was crucial in securing further investment and support for the aerial adventures of Ellehammer and a broader group of emerging flying enthusiasts. The Lindholm prototype was, then, not just a technological object, but worked as a kind of prefiguration that modelled a possible future in the present, one in which flying became a legitimate enterprise, as both material artefact and its social world emerged together through the prototyping process. In asking the question 'what next?' prototyping rehearses, or anticipates (Strathern 2010), the worlds into which such futurities can take hold.in approaching the craft of making flight machines in such a heterogeneous, untimely way, new institutions, sets of relations and discourses were also prototyped through Ellehammer's Lindholm flight machine.

Reorienting the Problem

Just a couple of years later the Lindholm prototype of 1906 was scrapped, the patent stabilization system was abandoned in the dusty archives of the patent office, and the patentbank was liquidated, seeing Viggo Knuth bankrupt while Ellehammer managed, somehow, to escape the entire business almost entirely debt free (Bang 2007: 33).

But the Lindholm flight machine did sufficient prototyping work to facilitate the emergence of a world in which flight began to be taken seriously, both at the level of local flying enthusiasts, and as part of a broader national discourse. While Ellehammer does not exactly disappear from the nascent Danish flying scene that he was instrumental in bringing about, he does become conspicuously absent as one of flying's public figures. In the period from 1908 forward, Kløvermarken at Amager[19] became a hub of flight activity with the construction of an aerodrome, the beginning of regular air shows and the training of pilots (Mygdal - Meyer 2001). Ellehammer did make some appearances but used a pilot, Frederik Molkte, to fly the 'Ellehammer standard', a bi-plane (as opposed to the tri-plane of 1906) with an improved engine capacity and folding wings. Although Ellehammer explains his absence from the scene in his autobiography in terms of a lack of funding for proper 'aerial experimentation,' a further passage qualifies this somewhat;

> "but I returned to flying just when the first flying accidents began to occur. It was one thing to rise into the skies, which was only possible with a machine in motion, and it demanded speed to both stay in the air and to land. And one couldn't just land anywhere; it required ample space to do so. It would have been much better if we had a flying machine that was able to lift itself vertically off the ground before gaining speed and could land anywhere with minimal spatial requirements. At this moment I realized that in order to become truly ideal, the flying machine had to be independent of speed" (Ellehammer 1931: 94).

[19] Amager is a district that lies in the south of Copenhagen.

Despite the advances made by the Wright's and others Ellehammer was concerned that the flight control system was not stable enough because it was bound together with the need for high speeds. As such he worked to re-orientate the problem of flight towards a machine whose movement was independent of speed, i.e., one that could take off and land vertically, hover, and still move briskly through the air. While the first problem-resolution phase resulted in a prototype that '*flew'* 45 meters at a height of 50 centimeters, the second phase decoupled the relation between movement and speed, and in the process entirely revamped the definition of 'flight'.

Through the course of this second phase many novel flying machines emerged. Similar to the first flight event, financing, patenting and publicing were primary elements, although the place where testing occurred was less important given the reconfigured nature of the problem. Ellehammer set up another financial institution to raise capital for the construction of a machine that would be convincing enough to enable further investment and allow full commercial production to get under way. Still focusing on control and stabilization, although this time independent of speed, Ellehammer registered patents in several countries,[20] which, like his first flight machine, used the weight of the pilot and motor as a pendulum for automatic stabilization. While there is not sufficient space here for an historical assessment of the helicopter, it appears as if Ellehammer was the second person in Europe, after Paul Cornu's 'flying bicycle' in 1907, to register a patent on a machine that could, novelly, achieve vertical elevation. As helicopter historian Kenneth Munson put it:

[20] Including Denmark, Norway, Sweden, Austria, Belgium, Germany, England, Italy, Russia and America.

> "the lifting rotors were of an ingenious pattern, consisting of two contra-rotating wings, the lower one being covered with fabric to increase the lift. At regular intervals around the perimeter of the wings were six vanes, pivoting on a horizontal axis. The rotor system was driven via a hydraulic clutch and gearbox, all designed by Ellehammer, and the rotor vanes' angle could be altered in flight by the pilot – an early example of cyclic pitch control" (Munson 1973: 98).

However, both of the early prototypes of this phase met with a swift demise.[21] The first, an unmanned attempt in 1912, rose off the ground for a few seconds but was destroyed when the hangar it resided in was blown down during a storm. The institutional investors refused to supply more capital and it was up to Ellehammer's brother to come up with sufficient funds for another attempt. When a French military

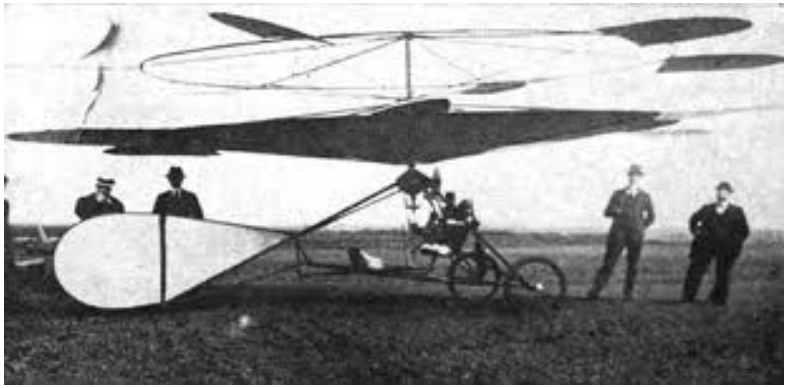

Figure 2: Early hybrid plane-copter prototype. Picture from archives of the Danish Museum of Science and Technology.

[21] The empirical data on Ellehammer's engagement with alternative flying machines is indebted to work carried out by the Danish historian Louise Karlskov Skyggebjerg.

contingent visited for a demonstration in 1913, a strong gust of wind twisted the tail of the machine and it crashed into the ground destroying one of the wings (see figure 4).

These two unfortunate scenarios plus the outbreak of the First World War put a temporary stop to Ellehammer's activities, although he did re-emerge shortly after this period to boldly claim that he had finally resolved the 'problem of flight' once and for all. The ultimate resolution for Ellehammer lay in the development of a hybrid plane-copter (see figure 5); one that could take off and land vertically, hover and

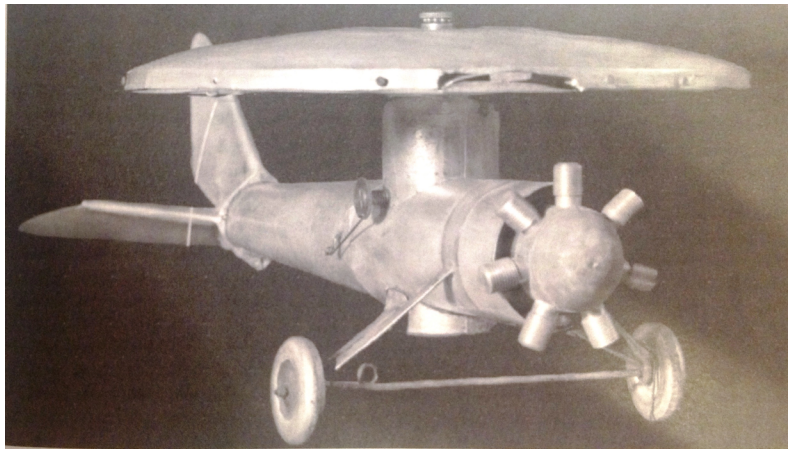

Figure 3: Model of Ellehammer's hybrid plane-copter prototype at the Danish Museum of Science and Technology. Photograph by author:

yet retain all of the functionality of a normal aeroplane (including its speed).What is interesting about this prototype is the fact that although it appears to be an ingenious solution to a range of issues,[22] it nonetheless failed to become a part of the flying landscape. As

[22] Although I have mentioned stability and aerial safety as a reason for Ellehammer's reorientation of the problem of flight, the First World War seems to also have made a particular impression upon him. From reading through some personal correspondence at the Ellehammer archives it seems that he considered the attributes of a plane-copter, i.e., the ability to take off and land vertically as well as hover for prolonged periods, to be a far more satisfactory method of conducting aerial attacks.

discussed earlier, we can think of a prototype as more than an object, it is also a receptacle for potential sets of relations that can form and take hold. Its art resides in asking 'what next'? questions that anticipate, or rehearse, worlds through which particular futurities can emerge. What was it then about this prototype that could not adequately anticipate the social worlds necessary to embed its own future? One possible explanation resides in the way Ellehammer deployed the patent system as a particular technology of ownership.

Modern patent law emerged throughout Europe mid-nineteenth century as part of a transformation within intellectual property law which had, by that time, become a distinct legal area replete with its own particular grammar and logic (Sherman and Bently 1999: 3). In 1893 the Paris Convention for the protection of industrial property was agreed and shortly after in 1894 a patent law was introduced in Denmark. Over the trajectory of his career, patenting became an increasingly important technology – a way, or means, of specifying relations between people and machines – through which Ellehammer sought out the 'what next.' In total he amassed over 400 patents registered in multiple countries within Europe and beyond (Karlskov Skyggebjerg 2006) and although it might be an overstatement to say that he was patent fixated, it seems that his eagerness to patent the plane-copter prototype was central in choking off the very relations necessary for its survival. As has become a staple of STS thinking, the new is constantly in search of allies and the art to its continued existence resides in attracting an increasing number of such allies (Akrich, et al. 2002a; Bowker 1994; Law 2002). As time went on, Ellehammer's approach to his newly reconfigured 'problem of flight' became increasingly embedded within the more delimited boundary making techniques of the patent system. Ellehammer entered into negotiations with both the Danish and English military over his prototype plane-copter (patented in the 1920's). The first set of discussions broke down after an engineer's assessment of the hybrid claimed that while having several advantages it would ultimately be inferior to a 'normal aeroplane' in terms of its speed and ability to carry loads. The second set of discussions pivoted on Ellehammer's refusal to provide detailed schematics of the machine's design and costs. In addition, the English requested that he provide a prototype that could be tested in a wind tunnel, which again, Ellehammer refused to do. While it is difficult to know the precise reasoning behind Ellehammer's lack of constructive engagement with the Danish and English military, what emerges from his autobiography is a clear sense of anxiety about his ideas being stolen, as well as both a growing reliance upon, yet a mistrust of, the patent system to protect them accordingly. Ellehammer recounts the story of demonstrating his new carburettor to Henry Ford while in America. Not masking his suspicion of misappropriation, he ponders the 'coincidence' of that very same design ending up in Ford's new tractor (ibid 2006: 101). More substantially, Ellehammer also claimed that another helicopter designer, Marquis Pescar, infringed upon his cyclic pitch control patent with the support of the French military. While Ellehammer managed to convince the Danish aeronautical society to lodge a complaint with its international equivalent, nothing came of the effort (Karlskov Skyggebjerg 2005: 53). Whether it is a case of once bitten twice shy is difficult to assess, but in many of his negotiations with potential buyers and manufacturers Ellehammer displays the same reticence to share any details of his prototype, focusing instead on the need to protect his potentially lucrative patents. This approach bears a striking resemblance to the Wright brothers who took the even more extreme decision to halt flying for several years out of fear that their patented design would be copied. While ultimately this approach did not stop competitor aviation companies encroaching on their claimed ownership rights, in particular the Curtiss company, it did result in many years of litigation

for infringement of their 'wing warping' patent.[23] Several American aviation historians suggest that it was the Wright's dogged insistence on interpreting patent law so narrowly that resulted in the lack of further development of their flying machine and the ultimate bankrupting of their company. In fact, some even go as far to say that it was the 'patent muddle' and the ensuing lengthy court cases that retarded US aviation development over the forthcoming years (Hallion 2003). While prototypes anticipate a particular version of the future, they still need to do enough work to allow for the possibility of such a future's enactment, that is, they need to hold open the space of transformation from potentiality to actualization. What I am arguing is that Ellehammer's approach to patents circumscribed this process of transformation.

Geoff Bowker (1994) has described patents as boundary making devices that rupture the flow of interactions constituting an entity's entangled lineage. In doing so, he argues, they tend to establish the inside and outside of objects. Marilyn Strathern (1996), in analysing the performative dimensions of property, reflects upon the ways in which patents for medical technologies are developed, arguing that any one '*invention'* is only made possible by the field of knowledge which defines a scientific community. While the social networks of medical technologies are long, patenting is what 'cuts' them (Strathern 1996: 524). Cutting, a term she borrows from Derrida, is a way of bounding, or truncating what otherwise could be an endless series of agencies. It is a performative practice through which some things come to belong while others are excluded. Prototyping new worlds requires an attentiveness to the art of performance. In trying to actualise the potentials of a prototype, delicate boundary work, or cutting technologies, have to be skilfully deployed. Patenting is one such performative technology that seeks to find the right moment at which to cut away the others involved in the lineage of any artefact;

[23] Wing warping was a precursor technique to aerilons (the small flaps on the wings that allow for lift and hence both horizontal and vertical control).

gathering together sets of potential relations and 'locating them in an owner' (Strathern citied in Barry 2001: 120). But cutting prematurely can be costly. It is a move that delimits the agency of both the things and people gathered. In Ellehammer's case, the drive for patent protection and the assertion of the right to withhold information to potential partners did just that. In decoupling the relation between speed and movement, Ellehammer managed to produce a prototype that anticipated a version of the world attractive enough to mobilise an infrastructure of support. Yet his over reliance on patenting also decoupled the prototype from that very same infrastructure at a critical juncture in the process, undermining his ability to make the transformative move from potentiality to actuality.

Conclusion

Otto Lilienthal reportedly once said; '*to invent a plane is nothing, to build one is something, to fly is everything*'(Crouch 2003: 51). The forms of mobility afforded by the airplane give it special claim to being one of the century's most transformative technologies. And while today flight and flying objects have become a stable part of our daily existence, the intervening period between Lilienthal and World War One threw up a veritable palette of aircraft figurations. This paper has focused on one of the key actors in early Danish aviation circles, J.C.H Ellehammer, the inventor-entrepreneur who *claimed* the honour of being the first man to fly in Europe in 1906. Ellehammer's production of flight machine prototypes, I have argued, were not just technological artefacts, they were, at the same time, receptacles for prefiguring specific versions of the future through which such technologies could find their place. His Lindholm flight machine did sufficient prototyping work to anticipate the emergence of a world in which flight began to be taken seriously. And this in two senses. Its emergence marks a key moment in the transformation of a nascent, yet sceptical, flying

public, while at the same time it also marks a moment when technology became an important part of this small nation's self-definition as it contemplated life in shadow of a more technologically sophisticated, and increasingly menacing, neighbour. Additionally, Ellehammer's untimely approach to 'the problem of flight' resulted in both new modes of organizing and new institutional arrangements, as both material artefact and its social world emerged together through the prototyping process. Such prototyping work was good enough to mobilize an ongoing infrastructure of support that facilitated Ellehammer in the continuance of his aerial adventures. However, in decoupling the relation between speed and movement during the second problem-resolution phase, Ellehammer also decoupled his prototype from the very same infrastructure of support he was so reliant upon. Both rapid technological development in flight machines and his over reliance on patenting as a means of excluding other actors from the prototyping process, sees a gradual disappearance of Ellehammer's hybrid plane-copter from the airscape of the day. If one way of conceptualizing prototyping is to suggest that it is what happens to sociality when the craft and agency of objects are approached in a particular way, what we can see, then, is that as the delimiting work of patenting becomes more important to Ellehammer, the anticipatory work of prototyping begins to model social worlds that are too difficult to sustain.

References

Akrich, M., et al.

2002a The key to success in innovation part I: the art of interessement. International Journal of Innovation Management 6(02):187-206.

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2002b The key to success in innovation part ii: The art of choosing good spokespersons. International Journal of Innovation Management 6(02):207-225.

Bang, O

2007 En beretning om grev Viggo Knuth - i opfinderen J.C.H Ellehammers kølvand. *In* Tekniske Museum Denmark Årbog. D.T. Museum, ed. Helsingør: Danmarks Tekniske Museum.

Barry, A.

2001 Political Machines: Governing a Technological Society. London: The Athlone Press.

Bowker, Geoffrey C.

1994 What's in a Patent? *In* Shaping technology/building society: Studies in sociotechnical change. W. Bijker and J. Law, eds. Pp. 53-74: MIT press.

Corsín Jiménez, A.

2017 The Prototype: More than many and less than one. *In* Prototyping Cultures, Art, Science, and Politics in Beta. A. Corsin Jimenez, ed. Pp. 1-18. London: Routledge.

Crouch, Tom D.

2003 Wings : a history of aviation from kites to the space age. Washington, D.C.: Smithsonian National Air and Space Museum.

Deleuze, Gilles, and Félix Guattari

1988 A thousand plateaus : capitalism and schizophrenia. London: Athlone Press.

Deleuze, Gilles, Félix Guattari, and Brian Massumi

2004 A thousand plateaus : capitalism and schizophrenia. London: Continuum.

Ellehammer, J.C.H

1931 Jeg Fløj. Copenhagen.

Gibbs-Smith, C.H.

1965 The world's first aeroplane flights (1903-1908) and earlier attempts to fly: HMSO.

Hallion, R.P.

2003 Taking flight: Inventing the aerial age, from antiquity through the first World War: Oxford University Press, USA.

Holbraad, Martin, and Morten Axel Pedersen

2017 The ontological turn: an anthropological exposition. Cambridge, UK: Cambridge University Press.

Hughes, T.P.

2004 American genesis: a century of invention and technological enthusiasm, 1870-1970: University of Chicago Press.

Karlskov Skyggebjerg, L

2005 Ellehammers Helikoptere. *In* Det Danske Tekniske Museum Årbog 2005. Pp. 39-64. Helsingør: Det Danske Tekniske Museum.

—

2006 Multiopfinderen J.C.H Ellehammer. Denmark: Klassisk Bil & MC.

Kornerup, N

2007 Kender du Ellehammer? København: Malling Beck A/S.

Law, J

2011 Heterogeneous Engineering and Tinkering.

Law, John

2002 Aircraft stories: Decentering the object in technoscience: Duke University Press.

Lévi-Strauss, Claude

1968 The savage mind: JSTOR.

Marres, N.

2005 Issues spark a public into being: A key but often forgotten point of the Lippmann-Dewey debate. *In* Making Things Public: Atmospheres of democracy. B. Latour and P. Weibel, eds. Pp. 208-217. Cambridge MA: MIT Press.

Munson, K

1973 Helicopters and other Rotorcraft since 1907. London: Blandford Press.

Mygdal - Meyer, T

2001 Da Danskerne Fik Vinger. Denmark: Gyldendal.

Sherman, B., and L. Bently

1999 The making of modern intellectual property law: Cambridge University Press.

Singer, B.

2003 Like sex with gods: an unorthodox history of flying. Volume 3: TAMU Press.

Strathern, M

1996 Cutting the network. Journal of the Royal Anthropological Institute 2(3):517-535.

—

2010 If I Were the Ethnographer. Prototyping cultures: social experimentation, do-it-yourself science and beta-knowledge, Madrid, 2010.

Whitehead, A.N.

1967 Adventures of ideas: Free Pr.

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