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ARTIFICIAL HORIZON: BLIND FLIGHT IN THE HISTORY OF VIRTUAL REALITY

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Abstract

Histories of virtual reality (VR) usually place its origins in computing. But this can be pushed back even further by considering early experiments in flight, principally in the endeavour to fly by instrument, that took place in the late 1920s and throughout the 1930s. This essay positions blind flight in the history of virtual reality and other immersive media in order to understand what sensory deprivation has to do with proprioception. Deprived of visual and aural senses, pilots were taught to reorient their perception of space using the artificial horizon as their guide. This essay uses the metaphor of the artificial horizon to discuss the relationship between sensory deprivation and sensory overload, both of which disturb the internal process that makes proprioception possible. Applying the method of media archeology places this study among others that have sought to historicise contemporary immersive media in unique ways, often with unexpected outcomes.

Keywords: Blind flight, immersive media, media archeology, virtual reality, proprioception, cybersickness, artificial horizon

Artificial Horizon: Blind Flight in the History of Virtual Reality

Dating as far back as the 1920s, engineers sought ways to trick the senses into believing that they were in a different place than they actually were. Today, this is one of virtual reality's most fundamental accomplishments. After all, how do immersive environments work? How can the user be made to sense a different environment? Massive efforts have been spent developing these technologies. By the 1930s, engineers were building flight simulators, becoming gradually more and more advanced, making it possible for pilots to dissociate from their natural environments and place themselves virtually in the sky. Concurrently, computer science engineers were developing innovative tools for human-machine interaction. Immersive media and computing converge in or around 1950 to inform the history of virtual reality.

Regularly, scholars trace the history of virtual reality through computing, pointing back to Sutherland's invention of the heads-up display, the universal screen, the mouse, the joystick, and more (Parisi, 2018; Rheingold, 1991; Grau, 2004; Huhtamo, 2013). Some consider flight simulation as a precursor to VR (Jeon, 2015; Taylor, 2013). But the history can be pushed back even further by considering early experiments in flight, principally in the endeavour to fly by instrument, that took place in the late 1920s and throughout the 1930s. This essay positions blind flight, or flying by instrument, in the history of virtual reality and other immersive media in order to understand what sensory deprivation has to do with proprioception. Blind flight refers to the practice of navigating a plane by instrument alone. In the 1930s, the practice involved pulling a hood over the cockpit to deprive the pilot of visual sensory input. Pilots were taught to reorient their perception of space using the artificial horizon, and other dashboard instruments, as their guide. Using this method, engineers sought to solve the problems associated with the disorientation caused by flying through fog.

I do not mean to place blind flight directly in the history of virtual reality as though it were a precursor to that technology. Rather, I will show how one relates to the other in a broader conceptual sense. The practice and philosophy of blind flight established in the early 20th century are what grew into a language of virtual reality. This history functions to defamiliarise virtual reality (in the broader sense of the term) through an historical continuum. Positioning blind flight in relation to virtual reality reveals ways in which sensory deprivation causes cybersickness.

While the history of virtual reality can be traced back to pre-historic times, some would argue rather that its technical underpinnings began in the early 20th century in the foundations of modern psychophysics and psychometrics. I show in *Visions of Electric Media* (2019) how a class of scientists known as the illuminating engineers sought to quantify and standardise interior lighting with the ultimate goal of creating artificial indoor spaces that simulated natural environments. The same story has been told in broader histories of early 20th century pschophysics and psychometrics (see for example Saunders and van Brakel, 2002; Johnston, 2001). These stories tell of scientists and technicians who built environments to make it possible for humans to transcend proprioception, those functions that allow us to perceive the world through our bodies.

For the purposes of this study, those senses include the eyes and the ears, two of the primary organs that control the ability to situate oneself in space. The practice of blind flying coincides with the reorientation of perception that happened over the course of the 20th century, including electric light interiors and other artificially manufactured environments. Psychometric and human factors studies converge the histories of simulation to bring about artificial ways of seeing (Franz and Ladewig, 2017).

Any discussion of virtual reality, of course, entails an application of Baudrillard's (1990) philosophy of simulation. Blind flight gives us a glimpse into a world that has not yet become simulated, in the Baudrillardian sense of the word. His "Precession of Simulacra" indicates a shift from natural to fully simulated perception converging so that the subject cannot tell the difference between them. In theory, simulation and virtuality are connected concepts. In this paper, I define simulation as the representation of space in a digital environment. Virtuality, then, is the sense of *being there* in a simulated space. Both concepts intertwine, in that they indicate a shift in sensation from one of natural observation to one of unnatural simulation. Simulations excel to trick the senses into believing that they are observing a different environment from the natural one. In the shift from natural to virtual environments that occurred throughout the 20th century, human perception also shifted from recognising the natural environment as one of common experience to the virtual environment as if it were natural. This shift coincided with the proliferation of computing and other digital technologies such as the Internet, computers, and, of course, virtual reality.

Virtual reality has both specific and general meanings. Specifically, at least at the time of writing, it relates to the technologies that include Oculus headsets and other Heads-Up-Display (HUD) devices. This is not to say that virtual reality is synonymous with simulation in a practical sense; virtual reality has applications far removed from simulating objects and people. More generally, virtual reality can refer to the ways in which perception has shifted from one of natural perception to one of simulated experience, in the postmodern sense. Michael Heim (1993; 1998) is keen on distinguishing between these two meanings of virtual reality. The former term was coined in 1987 by pioneer Jaron Lanier, and has functioned as the specific application of VR ever since.

Virtual reality existed long before the technology that makes it an immersive, interactive media. Engineers struggled throughout the 1980s and 1990s to bring VR to eager audiences. But during that time, perceptions were already shifting into sensory overload given everyday practices of vision and auditory manipulation in immersive media and computing.

The significance of this study lies in the way it historicises contemporary technologies of virtual reality to show how simulation has become the norm. Blind flight indicates the instruction of the sense to recognise the real as if it were virtual. VR does the opposite; the user is taught to recognise the virtual as real. This can be observed in technologies such as Oculus. Of course, the instrumentation and the applications of blind flight and virtual reality differ for practical purposes. What links these two concepts is the feeling of immersion and the reorientation of proprioception involved in constructing an artificial experience.

In virtual reality environments (VREs), as well as in flight, an important factor is to maintain a sense of *being there*, in the discourse referred to simply as *presence* (Biocca and Levy, 1995). Immersive environments are most effective when users experience presence. But in the research, presence is one factor that is foiled by cybersickness, the sense that one's body is in a different place than it actually is. Some symptoms of cybersickness include nausea, vertigo, and disorientation (Martirosoy and Kopecek, 2017). The literature on cybersickness in virtual reality is vast, and it intersects with research into the effects of presence and attempts to increase spatial awareness (the sense of *being there*) in VREs (Biocca and Levy, 1995). There appears to be an inverse relationship between *presence* in VREs and cybersickness; the more "present" the user feels in the VRE, the less cybersickness they will experience (Weech, Kenny, and Barnett-Cowan, 2019). While cybersickness is caused by a technical glitch in the simulation (i.e. a visual and/or mechanical lag), it affects the aesthetic quality of realism to the viewer (Stauffert, et al., 2020). That is to say, a user will feel present in an environment that feels more natural, more real. If the objective of the designer is one of verisimilitude, the goal of the virtual reality simulation will be to make the environment and the experience feel as real as natural space. The irony is that a simulation, by its very nature, is artificial – from the Latin *simulare*, to fake or pretend.

This present study is a work of media archaeology, and it should be stated up front that it owes a debt of gratitude to the theorists, practitioners and philosophers who spearheaded the discipline (Huhtamo and Parikka, 2011; Parikka, 2013; Kluitenberg, 2011; Marvin, 1989; Strauven, 2006). Media archaeology seeks to upset the established histories of technology, looking into the past for unusual or unexpected connections that trace into the present. While the exact method differs between scholars, it earns its name from Michael Foucault's *Archaeology of Knowledge* (1969). In a similar vein, Foucault outlines the genealogical method in *The Order of Things* (1975, p. 50). That is, while archaeology aims to uncover unexpected connections, genealogy traces them forward to find continuities and discontinuities of discourse. Genealogy is principally interested in rupture.

The genealogical method is appropriate in investigating the possible connections between blind flight and virtual reality (in the broader sense of the term). While I am trying to avoid indicating a precise historiographic connection between one and the other, a trajectory exists between the sensory deprivation technique of the former and the sensory overload implicated in the latter.

The Artificial Horizon

The key invention that made blind flight possible was Lawrence Sperry's invention of the artificial horizon around 1934 (Fig. 1). The artificial horizon took the place of several other key pieces of instrumentation (turn and bank indicators) (Fig. 2), making it easier for the pilot to navigate. It provided a reference for the visual horizon when sight was impaired, such as when flying through fog or at night. The artificial horizon maintains the pilot's orientation in space. In this instrument, we find the crux of spatial awareness. But what is most unique about the artificial horizon is the way in which instructors and the scientists who advocated for its practice described its utility.

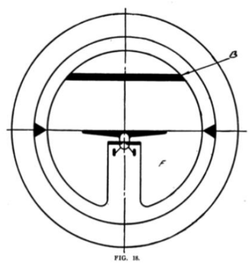

Fig. 1 "The Sperry Horizon," William Ocker, *Blind Flight in Theory and Practice*, 1934.

According to William Ocker (1934), the inventor of blind flight:

> The object of the artificial horizon is to introduce an instrument whose readings do not have to be interpreted and which will allow the pilot to fly in a manner similar to the way he has been trained and is accustomed to flying. This is accomplished in the Sperry Horizon by *simulating* the earth, sky and horizon on the instrument in such a manner that the pilot gets visual flight stimuli similar to those he receives when outside visual reference is available (p. 49, emphasis added).

Blind flight, as we shall see, requires a great amount of concentration as the pilot must learn to perform their duty without the use of their primary senses. Their attention is trained on a panel of instruments before them in the cockpit. While the visual aspect of reading the instruments is involved, the practice is situated in the mind in a virtual space. The practice of blind flight, then, is both haptic and virtual.

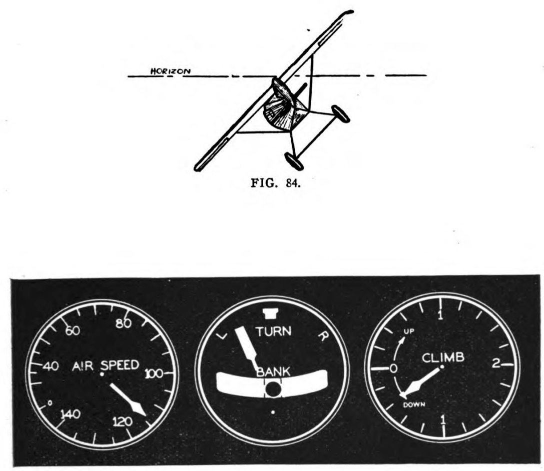

Fig. 2 Airplane and Turn and Bank indicators, *William Ocker, Blind Flight in Theory and Practice*, 1934.

To Ocker, the artificial horizon was the key instrument that made blind flight possible, a method to replace the turn and bank indicators that required so much concentration to operate. As Ocker (1934) continues he emphasises attention, describing the artificial horizon as a "system" through which the pilot replaces the real space surrounding them with a virtual environment in the mind (p. 142). The artificial horizon becomes a means to provide a "simulated" experience, leaving the earth behind.

Sperry's artificial horizon is no different from J. J. Hammond's television instrument. In a manner that might seem odd to a 21st-century reader, these two instruments fulfill their purpose in remarkably similar ways. Hammond models the airstrip. In the artificial horizon sits a model plane, functioning as reference to the visual horizon made invisible by fog **(**Fig. 1) ("Practical Lessons in Flying," 1932).

In the long run, or over the course of the 20th century, physiological sciences taught the body to reorient itself within the media (see for example Jeon). The artificial horizon stands metaphorically for that shift. This short period of sensory deprivation technique exemplified by blind flight constitutes the birth of the perceptual artificial horizon. Virtual reality now transposes this awareness, with the sensory overload within the media seeming more real than real.

Blind Flight

In the 1920s, flying was a deadly art. In anything but clement weather, pilots found themselves in mortal peril. Fog, clouds, nighttime, storms: the inability to see the natural horizon, their orientation to the land below, caused pilots to lose control of their craft. All manner of mysterious tricks worked on their proprioception. Lost in fog, pilots described the sense of disorientation (eventually revealed to be an aspect of the inner ear), making them believe they were flying straight when in fact they were plummeting to the ground (Miller, 1928).

Blind flight is a notable historical practice because it arose during peacetime; media discourse overestimates the effect of war (Baudrillard, 1995; Virilio, 1989). But the effects of simulation on human perception cannot be overestimated. Blind flight was a timely invention in the interwar period because of the budding commercial enterprise of airmail. In this context it would not have been seen as a staging ground for the lead up to war – not until Hitler's invasion of Poland in 1939. Blind flight emerged as a regular practice in the interwar period, the primary application of which was in the delivery of the mail. Independent carriers and the US Army corps competed against the speed of the railroads (Conway, 2006, p. 16). It was literally a race. The problem was that pilots had trouble flying at night and through inclement weather. This hurdle led scientists and engineers to develop new methods of flight, and new instruments to guide them. One was Sperry, and the other was Ocker.

Instinctual Flight, Flying Blind

In the dawn of the age of flight, daredevil pilots rode by instinct. "Instinctual" flyers, as they were called in the trade, relied on their guts to make it across the sky. Heroism, iconoclasm, masculinity: these were the traits of the ideal flyer. The pilot was brave to meet the challenge of rough conditions and dangerous situations; it was part of the job. Flight was appealing for its danger! An aura of *mystique* surrounds the instinctual pilot.

In instinctual flight, the practice becomes a reflex adopted by experience. Reflexes must be trained; flight is learned. Flying through the air, after all, is a practice unusual to the natural senses.

But in all actuality, natural instincts could not always be trusted. Pilots found that out the hard way; pushing the boundaries past safe conditions during the race to win mail carrier contracts, mysterious phenomena caused planes to nosedive into tailspins when lost in fog.

Amid the danger of "flying blind", the mystique of the pilot was sacrificed. That is, flying blind refers to planes caught in low visibility while "blind flight" refers to flying by instrument. The former is accidental and the latter is purposeful. There was nothing but pushback against blind flight. Pilots contested that their senses, both visual and aural, were at the height of their physical prowess. What measures required such a drastic shift in the practice of flight? According to Ocker,

> There has always been a rather studied dislike for instruments by the pilot. The pilot likes to feel that he is an artist at flight control, and in plying his art feels that his natural instincts are a better guide to the performance of his craft than any number of instruments (Ocker, 1934, p. 9).

In "Mystery of the Port of Missing planes Solved" (Miller, 1928), the author also describes this pushback:

> Flyers have recognized the menace of "blind flying" [flying blind] from the start, and one of the oldest tests for pilots requires them to stand on one foot with their eyes closed, under which circumstances it is difficult to preserve balance. But that a pilot could be misled with his eyes open and with turn and bank indicators on his instrument board to guide him, is a new discovery.

Sceptically, the author positions instinctual flight as the norm; this "new discovery" indicates that the flyer requires greater skill than just their senses. Ocker devised the system of blind flight particularly to solve the problem of tailspins. Up until Ocker hit the stage, downed planes in fog were quite a mystery.

Instinctual flight involves sight, hearing, and the kinesthetic senses, led by the function of the inner ear. As stated earlier, blind flight is haptic and virtual. In order to avoid vertigo, the pilot must ignore the other senses. In normal flight, the eyes and ears coordinate to give the pilot a sense of orientation to the earth. But in blind flight, the sense of sight is eliminated leaving only the ears to do the guiding. However, the ears are easily fooled – the turn and bank indicators were not powerful enough to register the spin. Enter the Sperry artificial horizon, invented so that the pilot could *see* the horizon without it being (visually) *there*.

For the instinctual flyer, the plane seems to change orientation while the earth stays static. The trained pilot experiences the opposite: "It seems during this early experience that instead of the plane banking the earth banked" (Ocker, 1934, p. 27). Ocker explained in retrospect that pilots flying in poor weather conditions continued to rely on their senses, which deceived them. In the literature, these sensations are referred to as *illusions*, *deceptions*, and *hallucinations*. There is a gross discrepancy between what the pilot feels and what is actually happening with the plane. Ocker and Myers attribute that to an illusion of the senses; but pilots trained to fly by instinct mistrusted the science. "The pilot contended that the instruments did not work in the clouds, yet they seemed to indicate correctly when in clear weather. This mistrust of instruments was not due to a mental condition of the pilot alone, but had a very definite connection with the physiology of the pilot" (p. 11). Ocker tried to instill the message that safe flight was a science, not an art. Learning to fly by instrument required not just ignoring the senses, but reorienting proprioception – the very faculty by which we orient ourselves in space.

It took years and much effort for him and his advocates to convince the training schools, much less the pilots, to learn how to fly by instrument. In 1932, *Flying Magazine* featured an article, "When Blind Flying is Advisable", indicating the turning of the tides. The author reveals himself to be a true adherent to blind flight, a practice that is bound to solve the problem of these mysterious tailspins. If the senses cannot be trusted, where does our orientation lay? "His only recourse is to detach himself completely from the dictates of his *natural* impulses, and to rely upon instruments which show the *true* actions of the airplane" (Tomlinson, 1932, p. 287, emphasis added). Notably, the author distinguishes between the natural and the virtual. Ocker's introduction of the virtual space constructed in blind flight fills in the gaps.

Several articles for young readers, such as those written for *Flying Magazine* and *Boy's Life*, dramatise the transition from instinctual to instrument flying. B.W. Leyson's "The Spectre of Fear" (*Boy's Life*, 1934), for instance, tells the story of a pilot's fight against an anthropomorphised storm. The story's purpose: to establish the benefit of the artificial horizon and to legitimise the practice of blind flight for adolescents. Leyson uses literary devices which heighten the dreadful experience of flying blind: "In their midst was a threat of storm, of danger, even death. He found it difficult to tear his eyes away from them. They held a peculiar fascination, attracting him by the glittering, unblinking eyes of a serpent holding a bird." At the heart of his story rests the artificial horizon, saviour of hero Bill Adams.

> But man refused to admit defeat. If to lose the horizon was to be deprived of balance, there was still a way out of the dilemma. Lacking a horizon while flying through a storm, he sought to design an instrument to replace the loss. Now the first of the "artificial horizons" rested upon the dashboard in front of Bill Adams … It replaced the lost horizon.

The story works as an advertisement as much as a dramatisation for young readers, encouraging the next generation to trust in the science instead of going with the gut. The story neglects the contemporary ambiance of the daredevil pilot. In fashioning nature as the villain, the artificial horizon is the saviour of the intrepid pilot.

The Ocker Test

Unable to rely on their sense of sight, pilots flying in foggy conditions would become disoriented and fall prey to an odd disorder of vertigo. The result was clear: the inner ear could not be trusted. In the early years of flight, physicians took advantage of the Jones-Barany, a modified barber's chair, to test a potential pilot's sense of spatial orientation. The spinning chair tested the function of the inner ear. The trainee would sit face-down in the chair, which would spin; a sensation of vertigo ensued. The trainee's ability to resist the sensation of vertigo made them a candidate for flight school.

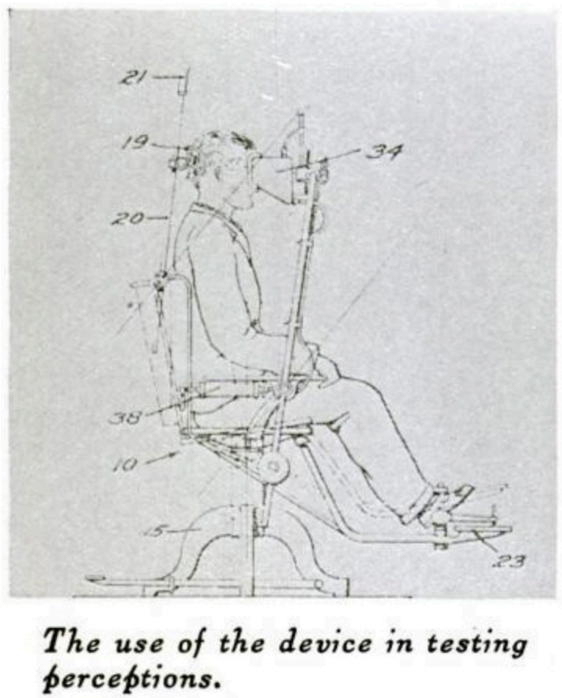

Fig. 3 "The Jones-Barany testing chair," in "Mental Cure for Vertigo," *Flying Magazine*, Sept. 1928.

Ocker modified the chair to demonstrate the benefits of blind flight. In addition to the chair, Ocker placed a box over the patient›s head, in which a turn indicator was mounted. Fig. 3 illustrates this manoeuvre. The candidate sits in the chair face-down, as in the Jones-Barany method. The box obscures their sight so that their attention is trained on the instrument inside. The chair stands in for their orientation in space, at once situating them in the present as well as providing the instigator of the proprioceptive deception. The candidate braces in the chair as it rotates, simulating the plane in a tailspin. When the proctor brings the chair to a halt, the candidate will experience the continued sensation of vertigo after the movement has ceased. The instrument within their sight testifies to the illusion of the phenomenon they are experiencing in the body.

Ocker (1934) named the chair-box instrument "the Ocker testing and training device", also known as the Ocker-Myers test. It served two coordinated purposes (p. 14). First, it demonstrated the effect of inner ear disorientation on one›s sense of proprioception, the cause of vertigo. Second, it provided evidence to support the argument for blind flight. "He will presently understand, not only that his sensations of movement and direction are unreliable under these conditions, but will readily understand and appreciate with what degree his sensations can depart from the actual movement taking place" (Ocker, 1934, p. 36). In effect, the Ocker-Myers test contributed to a fundamental shift in conception of spatial orientation. One could no longer rely on one's natural senses. Instinctual flight, the deadly art, would be a thing of the past.

Ocker's rhetoric describes the ways in which the system of blind flight merges human and machine. One would "become a part of" the artificial horizon. The instruments would become more than machinery. One would need to "auto-hypnotize" oneself in order to be able fly through fog (Spencer, 1928). Vertigo becomes a "false sensation" (Ocker, 1934, p. 36). One journalist described it as "coordinating the human brain" (Spencer, 1928). Thereby the instruments in fact function in place of the eyes and ears. All that was required was the faith of the pilot. But that was a long way off for Ocker. It took years, from 1928 when first demonstrations began until the early 1930s, for blind flight to gain a substantial following. "Instinctual flight" was so embedded in the practice that a massive re-education campaign, assisted by the Ocker-Myers test, was necessary to demonstrate the need for blind flight.

The Ocker-Myers test is a second-order simulation. Long before the flight simulator, the Ocker-Myers test "masks and perverts a basic reality" (Baudrillard, 1994). The pilot substitutes the turn indicator for their inner ear. An artificial navigation system emerges. The theory of blind flight was born.

Practice and Training

Patently rejecting the role of the visual in orienting oneself in space, "Practical Lessons in Flying" (1932) advertises, "The less you see the more you're going to learn". Sight is the main sense through which the pilot orients themself in space. The disorientation of sight causes vertigo. Therefore, when the pilot is blindfolded, they rely on the sensation of the inner ear. Concentrating on the instrument panel allows the pilot to forget their natural senses, instead relying on the guidance of the machine. Ocker and his colleague Carl Crane developed the process of blind flight for training. Two pilots were positioned in the plane, one at the front under a hood and the second, an instructor, behind.

Blind flight operated as the most reliable and safe way for pilots to learn how to fly – by reference to artificial instruments in the cockpit board. By extension, this requires the pilot to learn how to orient himself in a virtual space, set apart from and distinguished from the natural environment and the real horizon. The pilot learns to orient themself by the artificial horizon instrument that assists the pilot in the creation of a virtual space in the mind. "The pilot must instantly and subconsciously convert the readings of the instrument into a mind picture of what the airplane is doing" (Tomlinson, 1932, p. 330). As adherents would contend, this virtual space becomes second nature as the pilot learns the practice of blind flight. Through training, less and less attention is necessary to keep the plane oriented in space.

With regard to training, Ocker describes virtuality as the true, natural sense, quite removed from actual space.

> Experience shows that after a time the various senses, particularly the sense of sight and vestibular sensations become trained to the point where a correct impression of relative position is gained. It can be said, then, that orientation or spatial orientation during flight is obtained only after the «illusions" created by the labyrinth – eye stimuli have been corrected by experience (Ocker, 1934, p. 29).

Here again, Ocker returns to the notion of *illusions*, *hallucinations*, *deceptions*. The "correct impression" substitutes for the natural one. The trainee blossoming into a cadet leaves the earth behind to live in the virtual space of the mind, a space in which they simulate the world passing, made invisible, outside of the plane. Now, the simulated environment inside the hooded cockpit supersedes that of the real, actual environment.

Aside from the analogue instruments in the cockpit, very little technology is, in fact, involved. The instrument panel, flecked with radium paint so pilots could see at night, emitted a radioactive glow. In training, the pilot might feel that the instruments are referencing the real world outside of the plane. But with training, Ocker contends, the instruments will substitute for reality. Substitution then eases concentration. While Ocker was keen to describe the artificial horizon as a "system," in actuality it was more than that. He describes in his book the system as a "means towards an end," the end being a complete simulacrum (p. 120). If the Ocker Test indicates a second-order simulation, blind flight leads to a third. In practice, blind flight involved the reorientation of the senses toward the purpose of enabling pilots to navigate in simulated space. Importantly, it operates in an environment of sensory deprivation. Control boards replicated the environments of sight, with bodily sensations ignored in order to perform a task – flying an airplane.

Simulation

Where other scholars begin the discourse of virtual reality with flight simulation, I have pushed the timeline back at least a decade. When understanding the timeline in terms of sensory deprivation and overload, early experiments in flight simulation (during the interwar period) are little more than a blip. But some notes about flight simulation in this context are helpful.

Blind flight having gained prominence in the 1930s, the first flight simulators appeared around the time of the Second World War. The Link Trainer is widely considered to be the first technical flight simulator, invented by Ed Link in the 1930s (Allerton, 2010; Damos, 2007; Page, 2000). This story dovetails with the philosophy of simulation as it relates to war. In fact, a successful gunnery trainer pioneered during the Second World War to train war pilots was invented by the man who went on to introduce Cinerama in the 1960s (Taylor). The history of flight simulation also overlaps with that of immersive media.

The Link Trainer cut down on the costly amount of time that apprentice pilots spent in the sky. The device provided an on-the-ground environment in which the motions of the plane were simulated by an instructor. Given that the Link Trainer had as much of a visual component as the practice of blind flight – no actual horizon was visible or obscured – the apprentice created a virtual space in the mind. But more so than in blind flight, the experience was simulated in that the pilot would not actually experience motion sickness.

The Link Trainer marks the beginning of a long history of flight simulation, which merges with the history of virtual reality. In "The Virtual Flyer" (2015), Chihjung Jeon goes to great lengths to connect early experiments in flight simulation with the emergence of virtual perception: "A close look at the Link Trainer shows that we do not simulate immutable reality to create its virtual version so much as reconstitute reality into a state that is subject to simulation. Simulation and reality are co-produced" (p. 30). A degree further removed from reality, in the Link Trainer the apprentice learns to simulate the virtual space of the flight without having an initial reference.

Some years later, the Aerostructor, refashioned as the Gunairstructor gunnery trainer, marked the introduction of video to flight simulation. The important difference here arises in that these devices provided the trainee with a visual horizon projected in front of the model plane. As the history of flight simulation moves ahead, devices aim to mimic the actual experience of flight without the trainee having to imagine the space in the mind. Importantly, blind flight, and later the Link Trainer, both involved a certain amount of concentration on the part of the apprentice in focusing on the artificial horizon as if it were real. Both involve simulated environments of sensory deprivation in order to achieve that effect. But as flight simulation advanced, virtual environments became more and more visual. Eventually, virtual environments reproduce real-world settings in varying degrees of realism; viewers require less and less concentration to make it seem real.

Linked to the cinema and the HUD, the history of virtual reality has always been read as one of visual immersion. It should be noted, however, that the instruments involved in blind flight do not correspond directly with the instruments involved in modern VR systems. Establishing blind flight in relation to virtual reality marks a key difference between these two practices. Importantly, blind flight is immersive but not visual. It marks the construction of the virtual space inside the person's mind. If the discourse of virtual reality aims to make presence possible by means of greater realism, blind flight shows that simulation constructed in the mind without visual reference can be more real than real.

Conclusion

In *Blind Flight* (1934), William Ocker pictures a figure of a plane flying at a 45-degree angle to the earth (Fig. 4).

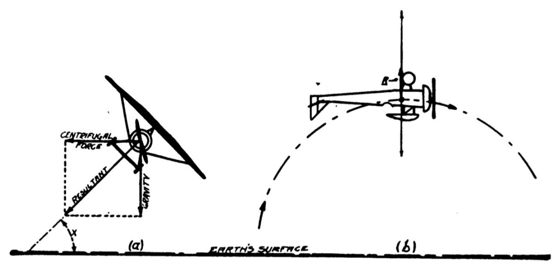

FIG. 5.

Fig. 4 "The resultant gravity and centrifugal force during a banked turn of an airplane and during a loop," *William Ocker, Blind Flight in Theory and Practice*, 1934.

He uses this figure to demonstrate the importance of the cockpit indicators (turn and bank indicators and the artificial horizon). But there are, in fact, at least two ways to interpret the image. Initially, it is seen as the plane banking at 45 degrees to the earth. Rotate the paper 45 degrees to the left and suddenly you see what the pilot sees. The earth has shifted, and the actual horizon is no longer level. This example illustrates the value of an artificial horizon in the perspective that it offers for those who choose to remain in the ground.

But for those who soared through the clouds, flight required pilots to experience unforeseen challenges to their senses: visual, aural, proprioceptive. As a metaphor for the transition from natural to simulated experience, and real and virtual life in the 20th century, the artificial horizon reveals to us a great many things. Preeminently, our experience of the world is always already mediated by some sort of technology, first and foremost the technology of sight. Over the course of the 20th century, human experience became gradually attuned to advanced technologies of the senses. This current study of blind flight shows that it is equally possible for engineers to design simulated spaces of virtual experience in environments of sensory deprivation as much as overload. This is not to compare the two but rather to reveal how both create virtual experience, one in the person's mind and the other in simulated, computational environments.

Blind flight deserves a place in the history of immersive media. Largely consisting of visual media (panorama, telepresence, etc.), immersive media coalesce in the virtual reality. Indeed, the history of immersive media is synonymous with virtual reality in many ways, as is the history of computing. Unlike other immersive media, however, the virtual space is created under the darkened, hooded cockpit. That is, immersive media can exist divorced from the visual, even the auditory. In the deep history of virtual reality, blind flight functions as a marker for the burgeoning experience of immersion instigated by the birth of the cinema just a few decades earlier. The immersive media have in common the construction of the virtual space, in the mind as much as for the eye.

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