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NONLINEARITY, MULTILINEARITY, SIMULTANEITY: NOTES ON EPISTEMOLOGICAL STRUCTURES

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Abstract: This paper addresses three paradigms in epistemological structures that could serve as preliminary classifications enabling a systematic approach to past and current media phenomena such as hypertext, diagrams and ubiquitous computing. Nonlinearity is discussed by Vilém Flusser in the context of "technical images." In his own approach to go beyond linear text, Flusser and his publisher created a digital version of his book *Die Schrift* on floppy disk (1987), enabling the reader to jump between chapters or to rewrite the text. Multilinearity is a concept that is revived within the diagrammatology discourse, transcending linearity through topographical ways of reading. Current examples can be found in arts and narratives such as Chris Ware's comics, who uses diagrammatics to blur the lines between the reader and the author. Simultaneity as a technological attribute is essential to current ubiquitous and pervasive technologies and services, and draws heavily on Heideggerian concepts such as readiness-to-hand and background. In this epistemological shift, the information is instantaneously organized according to the user's needs. Each of these epistemological structures offers a different idea about receiving and creating knowledge, information and communication, paving the way for narrative and media strategies that are more and more determined by a 'reader' becoming a 'user' and a 'text' becoming a 'service.'

Introduction

Linearity used to be an apriority of narratives, either as negative or positive precondition for any form of text. By looking at the current history of narrative clusters and representational structures, one can easily recognize the importance of linearity as an epistemological concept of perception. But the reference point of linearity loses its epistemological impact regarding the instantaneous, immediate display of data as seen in apps and services that deploy dashboards and cockpit-like interfaces.

With big data and real time analysis, and with the arrival of simultaneity in everyday life, linearity as the reference point for the perception of content has been transcended, much like this occurred previously with non- and multilinear narrative strategies.

Nonlinearity

When it comes to the concept of nonlinearity in contexts of representational/medial and epistemological structures, the discourses on informatization and global computer networks – evolving since the 1970s – are particularly interesting. These discourses do not only involve technological and sociological topics, but also epistemological and philosophical implications with reference to structure and representation of knowledge beyond discursive textual forms.

Even though concepts of alternative representations for displaying and gaining knowledge have a far longer tradition in the history of science: approaches to transcending "linear" written text can be identified already in early modern or even medieval times. Examples, among others, are taxonomic diagrams, attempts to develop a *taxonomia universalis*, a tradition reaching back to scholastic hermeneutics (cf. Siegel, 2009; Weigel, 2003; Schmidt-Biggemann, 1983).

However, the liberation of knowledge from its printed boundaries (e.g., books) due to telematics – a neologism (telecommunication & informatics) coined by Simon Nora and Alain Minc (1978) in their governmental study *L'informatisation de la société* – led to a renaissance of concepts on how to collect, structure, process, and communicate knowledge in ways not determined by a "linearity" of writing. These euphoric, partly utopian discourses might in some aspects appear naive to today's reader. Nevertheless, they can provide inspiring ideas for a possible future of how we share and develop our knowledge. In fact, it is symptomatic for the emergence of groundbreaking new (media) technologies that they inspire hopes about their potential for changing society. The advantage of such speculations is that they take place in an early adoption period of these technologies before they become standardized by economic/strategic requirements. It is a period in which the way of development and its possibilities are not yet determined (cf. Zielinski 2002, 2011).

Among influential writings of these times discussing new forms of knowledge structures, such as hypertext (Nelson 1984 [1974]), information visualization (e.g., Card, Mackinlay, & Shneiderman, 1999), and its broader implications for society (e.g., Lyotard, 1979), Vilém Flusser's late work is particularly interesting, since it combines these aspects in a non-trivial interrelation. The Czech cultural philosopher developed a media theory exploring the implications of evolving telematics and computer generated visualization (Flusser, 1985, 1987).

In a historical approach similar to Marshall McLuhan's media-historical investigations, Flusser, just as McLuhan, declared the end of writing as the dominant discursive and medial form. Similarly to McLuhan, Flusser identifies a interdependence between human cognition, society, and technological (especially medial) inventions. But in contrast to McLuhan, Flusser emphasizes the impact of *linearity* of written text: the invention of the alphabet enabled historical thinking beyond myth and modern science in its discursive form (Flusser, 1985). It does so not only due to its preservation of information; rather, the linear structure of writing "shapes" the human way of thinking, reasoning, arguing, etc., to become linear processes; the linear structure of the concept of time might be the most significant effect.

Flusser identifies a fundamental shift of these existential preconditions in the rise of the "technical images" at the beginning of the 20th century. In contrast to traditional images, these images are generated by a technical apparatus such as the photo camera, or more advanced, the computer. But the

epistemological implications are more important than the technical conditions. According to Flusser, technical images do not represent objects – they "project" concepts. They "make concrete" abstract models, and thereby create something new, rather than representing existing things (for Flusser, also a photography is not a representation, but a projected concept determined by conditions of the photographic apparatus and decisions made by the photographer). In Flusser's analyses, writing is currently transcended by operating, thinking, and communicating through technical images. This has radical effects on our *forma mentis*: linearity is going to be replaced by new ways of thinking, beyond discourses of cause and effect. Instead, a thinking associated with images becomes possible, reflecting the chaotic reality of the world we live in, where thinking "in probabilities" instead of linear causalities is required (Flusser, 1985).

This Flusserian paradigm change is significantly supported by shifts in media landscape. For Flusser, mass media is an effect of the linear condition: a sender is discursively sending Information to receivers, without dialogic possibilities. In contrast, artifacts such as the telephone or networked computers enable dialogues between individuals. In the case of telematics, Flusser saw a possibility for exchanging technical images, for creating them together with other people. He developed this idea as a utopian concept of "telematic society" (Flusser, 1985).

However, Flusser found himself in a paradoxical position. He, who claimed the end of writing, was a man of letters. An author who did not even use a computer to write his texts. According to an interview about his last publications (Flusser, 1989c), Flusser tried to transcend these linear boundaries by, first of all, experimenting with "scientific fiction" in collaboration with the French artist Louis Bec, who created speculative images (cf. Flusser, 1989a); further, by publishing a collection of essays as *pre-texts*, which were supposed to be transformed into video images (Flusser, 1989b); and finally, by a digital version of his book *Die Schrift* (Flusser, 1987), distributed on two 5,25" floppy disks – which is particularly interesting since it could be described as an ebook before the ebook.

The floppy disk version of *Die Schrift* does not only provide its text in a digital form, but also enables direct navigation to selected chapters, full text search, additional information, and the possibility to actively change parts of the text by the reader – or *user*. The interface (see Figures 1 to 4) does not look spectacular compared with today's standards, but at the time it was an exciting way to experience a book – and to bypass its linear structure. Thanks to a collaboration between the Vilém Flusser Archive at the Berlin University of the Arts and the University of Freiburg's Department of Computer Science, the electronic book can be experienced online as an emulation (www.flusser-archive.org).

Another project Flusser was involved in is the "Flusser Hypertext", developed in the context of a research project on electronic books at the Karlsruhe Institute for Technology Assessment and Systems Analysis (ITAS) at the beginning of the 90s. Based on his lecture "Schreiben für Publizieren" [writing for publishing] (cf. Flusser, 1989d), the hypertext was built in collaboration with Flusser. The team at ITAS was influenced by Flusser's *Die Schrift* (cf. Wingert, 1996). Here, in a chapter on computer-based reading, Flusser discusses a new kind of reader who is *actively linking* information – without referring to the term "hypertext":

> The future reader sits in front of the screen to call up the stored information. This is no longer a passive taking in (pecking) of information fragments along a prewritten line. This is more like an active accessing of the cross-connections among the available elements of information. It is the reader himself

> who actually produces the intended information from the stored information elements. (Flusser, 2011, p. 153)

The researchers at ITAS used Flusser's lecture as content for the "Flusser Hypertext Prototype 2," built on Apple's authoring system HyperCard. It contains the audio recordings of the lecture, the transcribed text, further information Flusser implied during his lecture (including images), and space for annotations. The hypertext is built as a "T-structure": the "horizontal" level contains Flusser's lecture, the "vertical" levels the additional, *deeper* information.

The structure and interface of this hypertext are particularly interesting. The pages are organized in reference to classical file cards (see Figure 5), relating to the "desktop metaphor" in order to provide orientation by referencing the physical world. The user can navigate through the horizontal level by clicking the numbered tabs, simultaneously listening to the audio recordings. Browsing to the vertical levels is possible by clicking the small squares attached to every linked word; the number of the squares indicates the number of levels.

The main menu (see Figure 6) is unusual: the hypertext's sections are displayed as a map, utilizing the concept of overlapping windows (cf. Kay, 1993). Through the element's topological arrangement, the researchers tried to provide an overview in order to counteract the "lost-in-hyperspace" effect. At any time, the user is able to return to this "apollonic" view – the rational, controlled perspective (Nietzsche) – to regain orientation (even though the orientation has its limits, as the critical number of overlapping windows indicates). We will come back to this apollinic promise of the topological in the context of discussing diagrams. Thanks to the above-mentioned collaboration, the Flusser Hypertext is available online as an emulation (www.flusser-archive.org, http://bw-fla.uni-freiburg.de).

The Flusser Hypertext could not be completed, and reached only prototype stage. Nevertheless, as an artifact of these times it provides enlightening insights into the optimistic attitude towards this seemingly "nonlinear" new medium. This attitude was still influenced by Theodor Holm Nelson's original hypertext concept dating back to the 70s (Nelson, 1984 [1974]; see also xanadu.com). In the following years, the notions of hypertext and nonlinearity became deeply interweaved. The German standard book *Hypertext* by Rainer Kuhlen (1991) describes its subject as "a nonlinear medium between book and knowledge database" – here, nonlinearity is defined as "free navigation in complex networks"[1] (Kuhlen, 1991, p. 6).

But even though the Flusser Hypertext's structure is determined by a logic of file cards – the groundbreaking paper technology for arranging information (cf. Rayward, 1975), giving the impression of loosely joined information bits, the hypertext unveils its *linear* structures as soon as it is used: the horizontal and vertical "T-structure" of the Flusser Hypertext makes it easy to identify this linearity. But also in cases of more complex hypertexts, and even if other media is involved (cf. "hypermedia"), a linear dimension is unveiled by the exploring user while he "threads" its content to a line. This is why we would like to suggest the term *multilinearity* – with all its implications – instead of nonlinearity when it comes to analyzing hypertext and similar phenomenons.

Multilinearity

As it turns out, even nonlinear representational structures tend to be linear after all. This very fact is reflected in the notion of multilinearity, which relies heavily on visuality. Looking at pictures, one does not follow a predefined linearity, but as soon as the visuals are not perceivable with just one look, the

[1] „Ein nicht-lineares Medium zwischen Buch und Wissensbank. […] Sie erlauben den ‚Lesern' von Hypertexten eine freie Navigation in komplexen Netzwerken."

gaze becomes linear, tracing view-lines on the picture, creating connections, following axes and perspectives, even gazes from figures portrayed.

These mechanisms can be seen in current examples we already touched upon, like the hypertext, but they also predate the electronic age considerably. They apply especially to visual storytelling, from earliest examples of cave inscriptions to panel paintings and picture stories such as comic strips. Most of these arrange their pictorial elements in a linear order, but this order cannot be sustained throughout the reading. It is instead dissolved into multilinear dimensions, enabling the reader to switch back and forth, looking at both the overall layout and the single elements, following one's own path throughout the narrative, lingering through space and time of the text or story. This practice becomes eminent especially in diagrams that are depicting circumstances both at once and in detail.

Studies on diagrammatic aspects have become popular in the humanities. In the context of the rising interest on images as subjects of research (trying to overcome the scriptocentrism of the linguistic turn), diagrams – strange hybrids between text and image – promise an "operational iconicity" (Stjernfelt, 2007; Krämer, 2009): they unveil an invisible *structure* of their signified object (cf. Peirce, 1998). By manipulating the diagram, this structural iconicity enables a speculative experimentation with possible formations of the represented object. When it comes to intelligible objects (models, theories, etc.), a diagram is more than a representation; it *constitutes* its object by making it visible – a recursive hermeneutic operation (see Figure 7).

One significant precondition of this iconicity is the diagram's *topological* appearance. Even though sentential representation systems (writing, mathematical notations, etc.) also have a topological, albeit rather linear structure (written on a page, displayed on a screen, etc.), the positioning and orientation of diagram elements have specific meanings: elements above might signify greater importance, element groups might signify similarity, and so on. This topological apriority – enabling an apollinic overview – can be an advantage of diagrams compared to sentential representations (cf. Russel, 1988).

A similar interest in the diagrammatic comes from cognitive science. Although the referentiality of diagrams is also an important aspect, these studies focus particularly on the topological structure. One general assumption is that visuo-spatial characteristics, enabling spatial indexing (drawing conclusions from the positioning of elements; cf. Larkin & Simon, 1987), can be more effective compared to sentential representations when it comes to fast information retrieval (cf. Cheng, Lowe, & Scaife, 2001).

But even though this "simultaneity of the overview" (Krämer, 2002, p. 117) is an essential aspect, the process of "reading" a diagram takes place as temporal sequence (Cheng, Lowe, & Scaife, 2001): after acquiring an overview and finding the element searched, one needs to – multilinearly – trace its relations to other elements in order to derive information from the diagram.

Thereby, the often-claimed opposition of sentential and diagrammatic representations dissolves: writing, for instance, includes diagrammatic aspects, like its arrangement on a surface (Krämer, 2009); diagrams, for instance, show linear structures as soon as they are used. Hence, "the diagrammatic" and "the sentential," or the linear, appear to be rather two poles of a scale within which representational artifacts can be arranged (Cheng, Lowe, & Scaife, 2001). It becomes clear that diagrams are not *per se* "better" than sentential representations; and neither is multilinearity compared to linearity. In fact, it depends on what cognitive effects should be achieved (Larkin & Simon, 1987). Sentential structures might be more appropriate, e. g., for

narrative formats where a storyline flow is important. And the simultaneity of diagrams might be more helpful for fast information. But in the end, it is a combination of both.

A certainly outstanding application of multilinearity to narrative storytelling can be seen in the works of Chris Ware, a Chicago-based comic author who is using a diagrammatic approach to expand both time and space, enabling the reader to develop the narrative autonomously. In his most famous Book, *Jimmy Corrigan, the smartest Kid on Earth*, he uses several diagrams, the biggest one being a foldout map from the interior of the dust jacket. This map shows the storylines of the protagonist, Jimmy, but also includes a lot of information that is not included in the book, such as the immigration of Jimmy's paternal great-great-grandfather and the capture, transportation, and sale of Jimmy's stepsister Amy's ancestors as slaves. This diagram opens up a much larger stage and historical perspective, contextualizing Jimmy's life within a long historical sequence of tragic and lonely characters. It offers a perspective that is usually reserved for third-person narrators and enables much more immersion and depth than a linear representation could offer (see Figure 8).

In order to understand what is happening here, the reader needs to gather some background information, and on top of that be able to decipher this form of storytelling. These skills are the topic of another diagram on the first page of the book, where Ware ironically tackles this "new pictorial language."

According to Ware, this particular diagrammatic grammar is "good for showing stuff" while "leaving out big words" (Ware 2000). The starting point of this diagram is one single frame that is then dissolved into different layers, explaining the mechanics and conventions at use. So while offering an explanation, it requires at the same time a reader already conversant with its idiom of symbols (see Figure 9).

The diagram reveals the close relationship between comics and information design by using a flat, simplified cartooning style, where characters and objects resemble pictographs or ideograms (Cates 2010). The process of signification in this case is less a matter of resembling the thing they represent, and increasingly a matter of symbolic conventions. Cates points out that this "stylistic transparency" (Cates 2010, p. 98) approaches the semiotic directness of language, and that both comics and diagrams share iconic drawings as their "natural vocabulary." He argues that "the diagrammatic potential of comics allows the pictorial space of the page to pull away from strict, camera-like storytelling into the pictorial equivalent of synopsis, analysis, or explanation" (Cates 2010, p. 100). These modes of representation follow multilinear, circular and recursive directions, which are constantly produced by the reader and therefore provide multilinear narratives while relying on icon-like symbols. Ware states that he aims for drawings so simple that "when you see them you can't make yourself not read them" (Raeburn 2004, p. 20). This instantaneous recognition is the condition for the simultaneous reading, for the instant sense-making that is used for the interfaces of contemporary apps and services.

Simultaneity

Simultaneity is not only the basic paradigm of current tracking apps and services such as the numerous self-quantification tools or web analytics dashboards and metrics, but is the precondition of general human-machine interaction on a much broader scale. If one expands the definition of narratives and of media strategies towards connecting, supplying, and rendering information, then we can look at current paradigms that dominate our contemporary experience with information, shifting from a linearity-based epistemology towards an instantaneous simultaneity. But what are the preconditions and predecessors of this simultaneity, of this *instant sense-making*?

With technological object cultures becoming unreadable, even imperceptible, we see an avoidance of the subject as an agent of sense-making. Bot-based communication has surpassed human generated traffic on the Internet in 2013 (incapsula.com/blog/bot-traffic-report-2013.html), and networked computation no longer relies on the human based, hermeneutic signification that was so central for the epoch of scripture. The network is literally and metaphorically at the core of the information, the communication and the text, connecting and reading, writing and recording without the need for human interference. This is well reflected in the paradigm formulated by Winograd and Flores in 1986, paraphrased by Hookway: "the user is 'driving,' not 'commanding'" (Hookway 2014, p. 147). The best user experience is rendered when the user is not aware of himself as being the user of a program, but experiences himself as the one performing a task without noticing the mediation.

The digital technology in place has lost its mechanical transparency, but kept its ability to exert instant control. Hookway traces the genealogy of these current interface paradigms back to wartime aviation and pilot plane systems developed during WWII and thereafter: "Flight is and always has been a mediated activity; even before the airplane cockpit was identified as a distinct spatial enclosure, the central problem of flight was one of establishing the mediations that would allow for the production of control" (Hookway 2014, p. 37). This production of control becomes particularly important when visibility is impaired, and it is crucial to provide instant essential information and feedback to the pilot. And in order to be instantly readable, the interface uses diagrammatic representations as simple as iconic drawings. The Kinalog Display System, which was put to use in 1959, indicated pitch and roll as relation of the wings to an artificial horizon with a simple diagrammatic relationship in order to create a maximum of compatibility between pilot and cockpit (see Figure 10).

This paradigm of User Experience now draws from the simulation of natural interaction, from multimodal input and output such as voice, gesture or touch, from instant feedback, in order to achieve the greatest compatibility between user and machine, between reader and text. The Embodiment of the cockpit transformed into Heideggerian concepts such as readiness-to-hand and presence-to-hand, with the tacit and subconscious control of the automobile as the model for interface design (Winograd and Fernando, 1986; see Figure 11).

In order to establish this unobtrusive information and control, technology needed to dissolve into the environment and become invisible itself. The most effective, ubiquitous, and pervasive computing therefore is seamlessly integrated into the ambience. The theoretical underpinning of this development again draws from Heideggerian concepts, formulated in 1991 by Mark Weiser, who is considered to have coined the term "ubiquitous computing" and "calm technology" as a chief scientist at Xerox Parc in the 1980s. He and his co-authors write that the most profound technologies are the ones that disappear, that integrate seamlessly into the everyday life and are no longer distinguishable from it. Whereas this idea remained more or less speculation in the 1980s, it rapidly became reality with the development of sensors, APIs and the so'called "Internet of Things," which is still in its very early stages. But one can already see that technology becomes background (*Hintergrund*), becomes a second, artificial nature. With the rise of touch as the main mode of input, the interaction becomes instantaneous, natural and intuitive. And with the adaption of cockpit-like interfaces, with the usage of icons and small diagrams, of dashboards and live visualization of data, technology even remains unobtrusive when it is visible. The representation of one's health, of one's sleep cycle, one's athletic achieve-

ments and so forth with the numerous apps and services integrated into mobile devices is actually displaying data that has been invisible until now. By manufacturing this instant, simultaneous visibility of the invisible, the media itself becomes invisible, becomes backgroundable and dissolves into the environment.

Real time data is no longer obtained from the mechanical devices it used to rely on in the cockpit of the pilot, but is gathered from all kinds of sources, from sensors, tracking tools and other metrics, quantifiying and measuring performance, status, activities from heart rate, body weight and sleep cycles to click-through-rates, page impressions and sales objectives, from temperature to 'likes' and engagement on social media.

Simultaneity applies to the tools and tactics we have seen in the non- and multilinear strategies: speculative experimentation creates the represented object by making it visible with a recursive hermeneutic operation, which can be found at the core of web-performance analysis and optimization such as SEO (Search Engine Optimization) as well as the quantified self apps and services such as health trackers. Iconic and diagrammatic representation enables a quick and intuitive understanding of the quantified data, producing an apollinic overview and effective exertion of control. But simultaneity adds another feature: it not only allows but *demands* instant interaction, as it no longer provides a text that requires just passive reading, but data that deliver motives for actions and decisions. Simultaneous media can no longer be understood with the concepts of linearity or multilinearity, but needs additional consideration of the instant character of interaction that is required by the user.

Figures

Figure 1: Welcome screen of Vilém Flusser, *Die Schrift. Hat Schreiben Zukunft?*, floppy disk edition. Copyright: European Photography, Andreas Müller-Pohle.

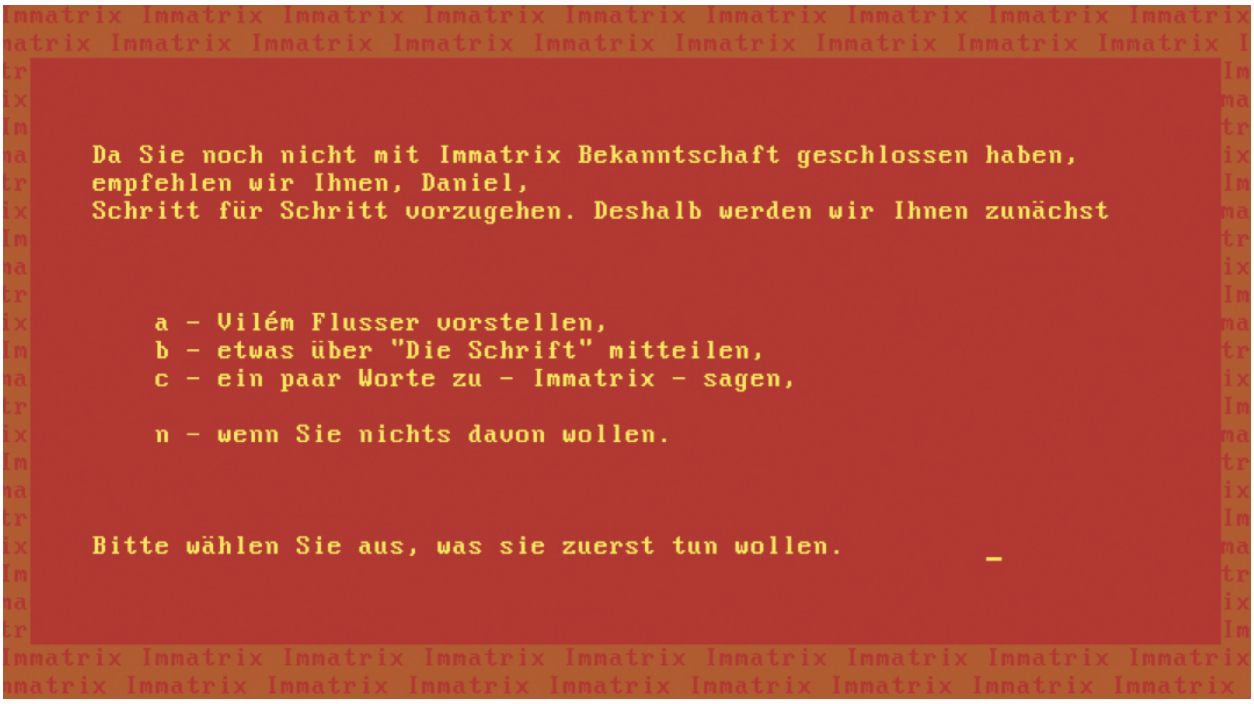

Figure 2: Main menu.

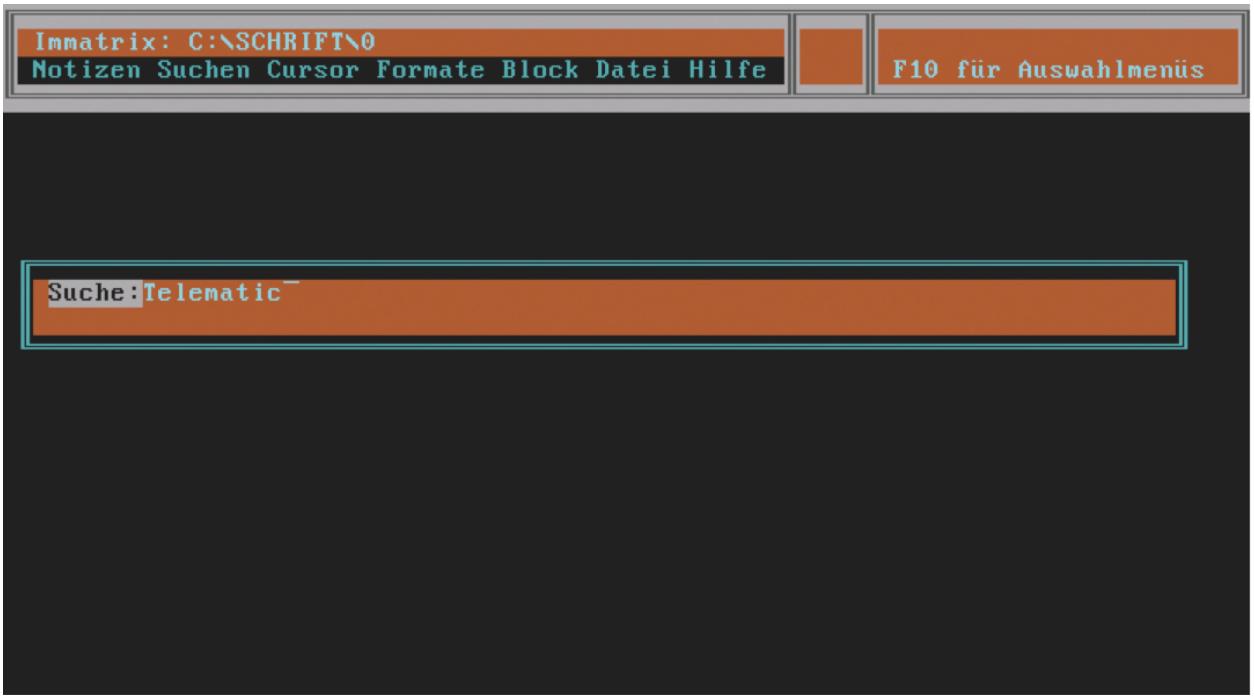

Figure 3: Field for full text search.

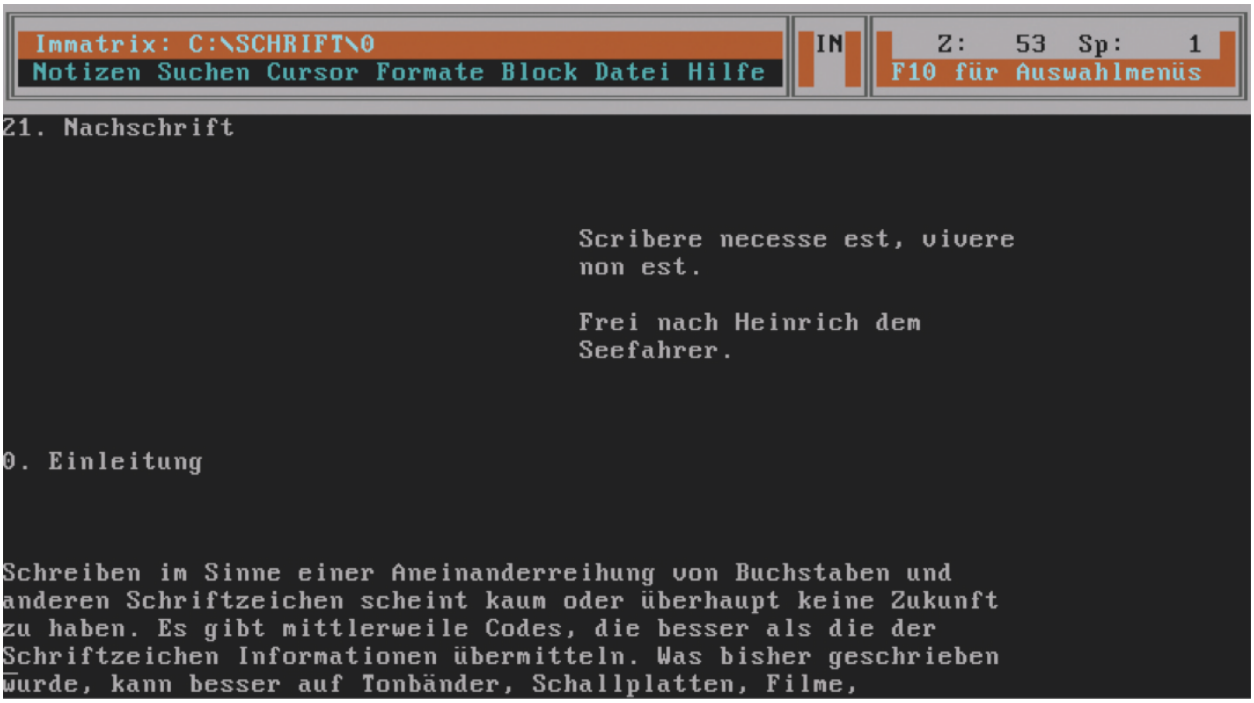

Figure 4: Full text view and content menu.

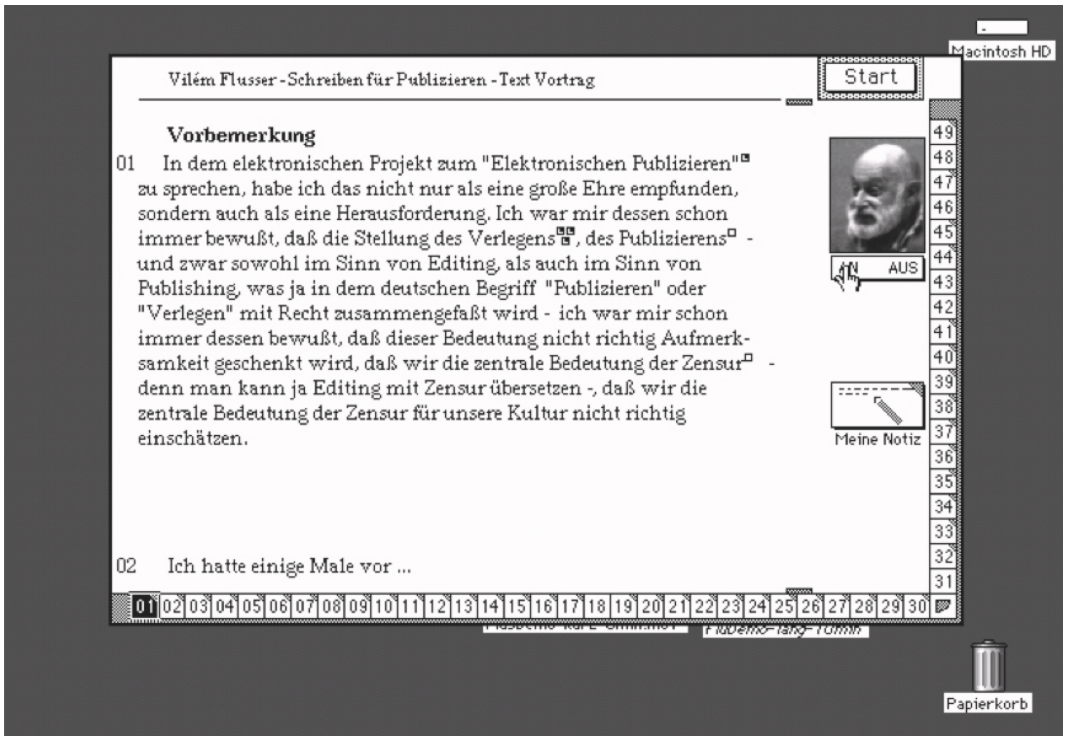

Figure 5: Content card of the Flusser Hypertext (running on Mac OS9), including "horizontal" links (tabs) and vertical links (small squares attached to words of the text). Copyright: ITAS, Karlsruhe Institute of Technologie; Apple Inc.

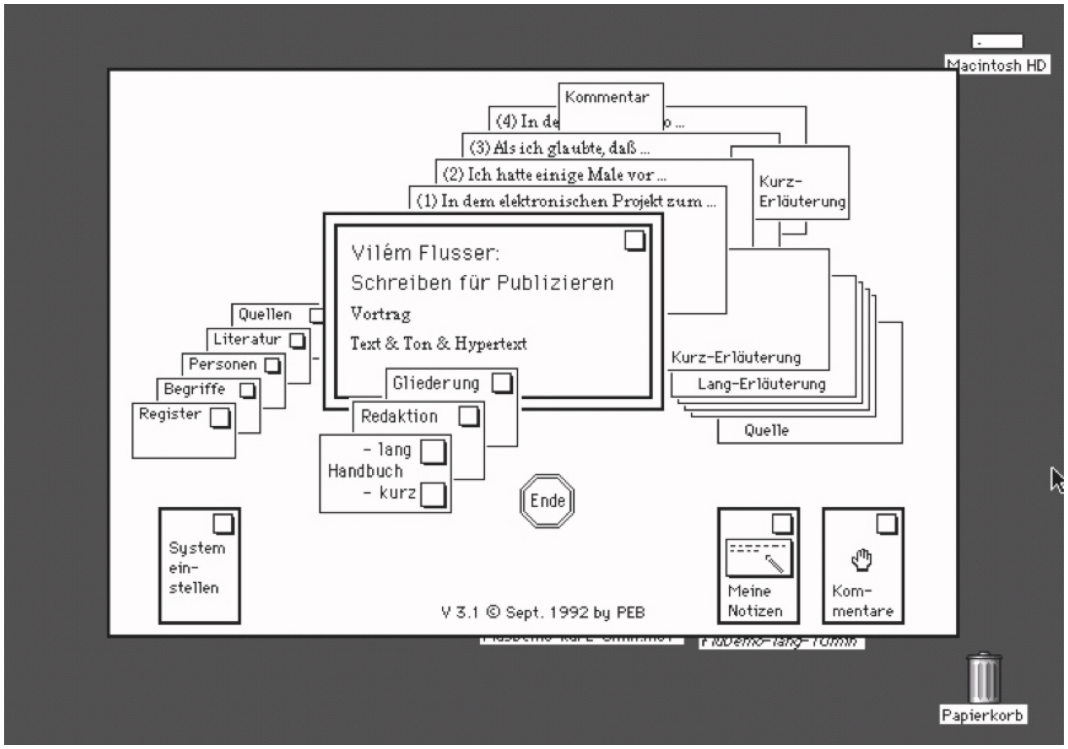

Figure 6: Flusser Hypertext main menu – a map with overlapping windows.

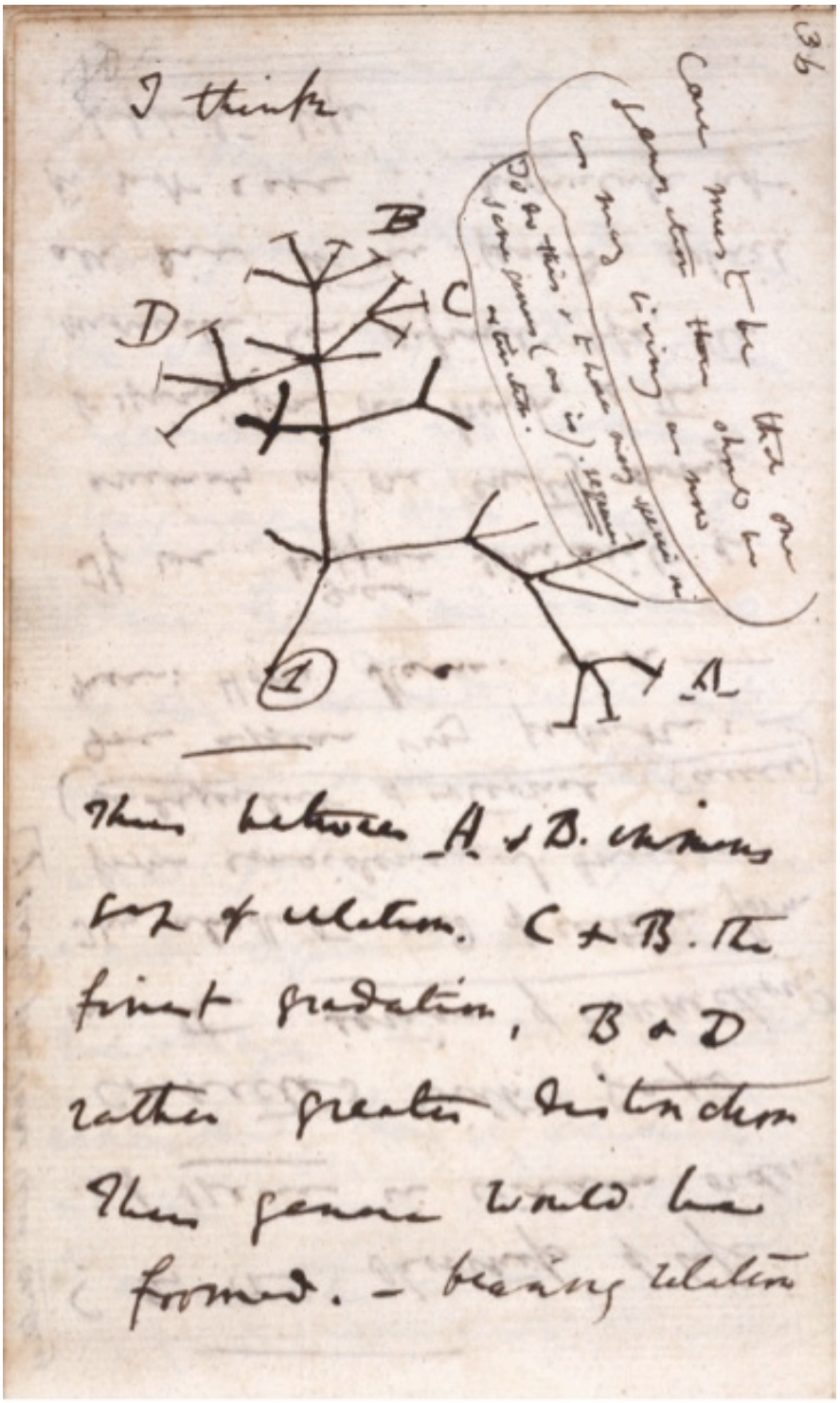

Figure 7: Charles Darwin's "3rd diagram" (1837), Notebook B, also known as "Darwin's corral". An attempt to grasp such a spatial and temporal highly abstract concept like evolution. The sketch's branches explore a possible "structure" of the evolution of some species and the extinction of others. (Cambridge University Library, dar. MS 121, fol. 36. Reproduced by kind permission of the Syndics of Cambridge University Library.)

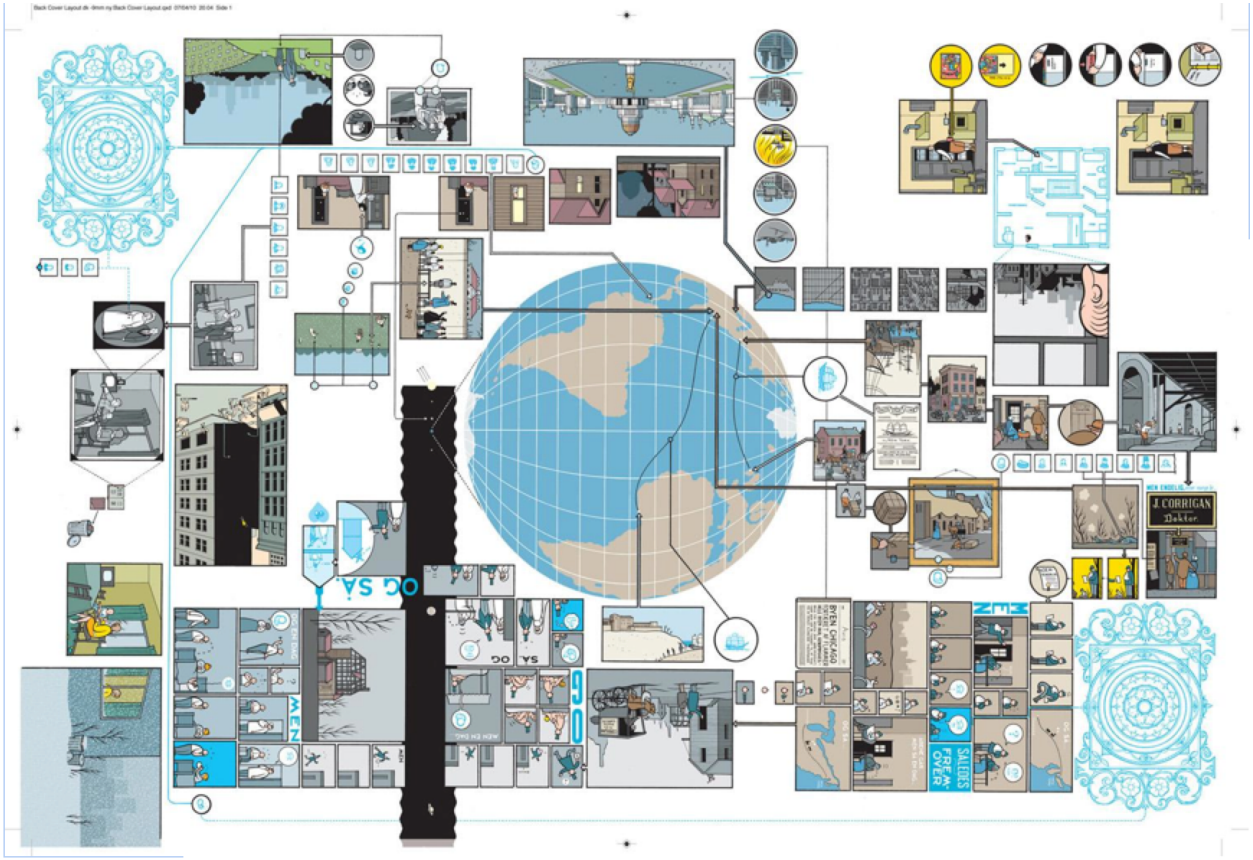

Fig. 8: Chris Ware's Diagram on the interior of the dust-jacket from *Jimmy Corrigan, The Smartest Kid on Earth*. This Map not only conceals certain details within the story and life of the protagonist, such as his hidden comic collection and some glimpses inside the life of his grandfather, but also suggests a much deeper historical background of the story, displaying both the immigration- and slave-routes from the 18th and 19th century. Copyright: Chris Ware/Pantheon

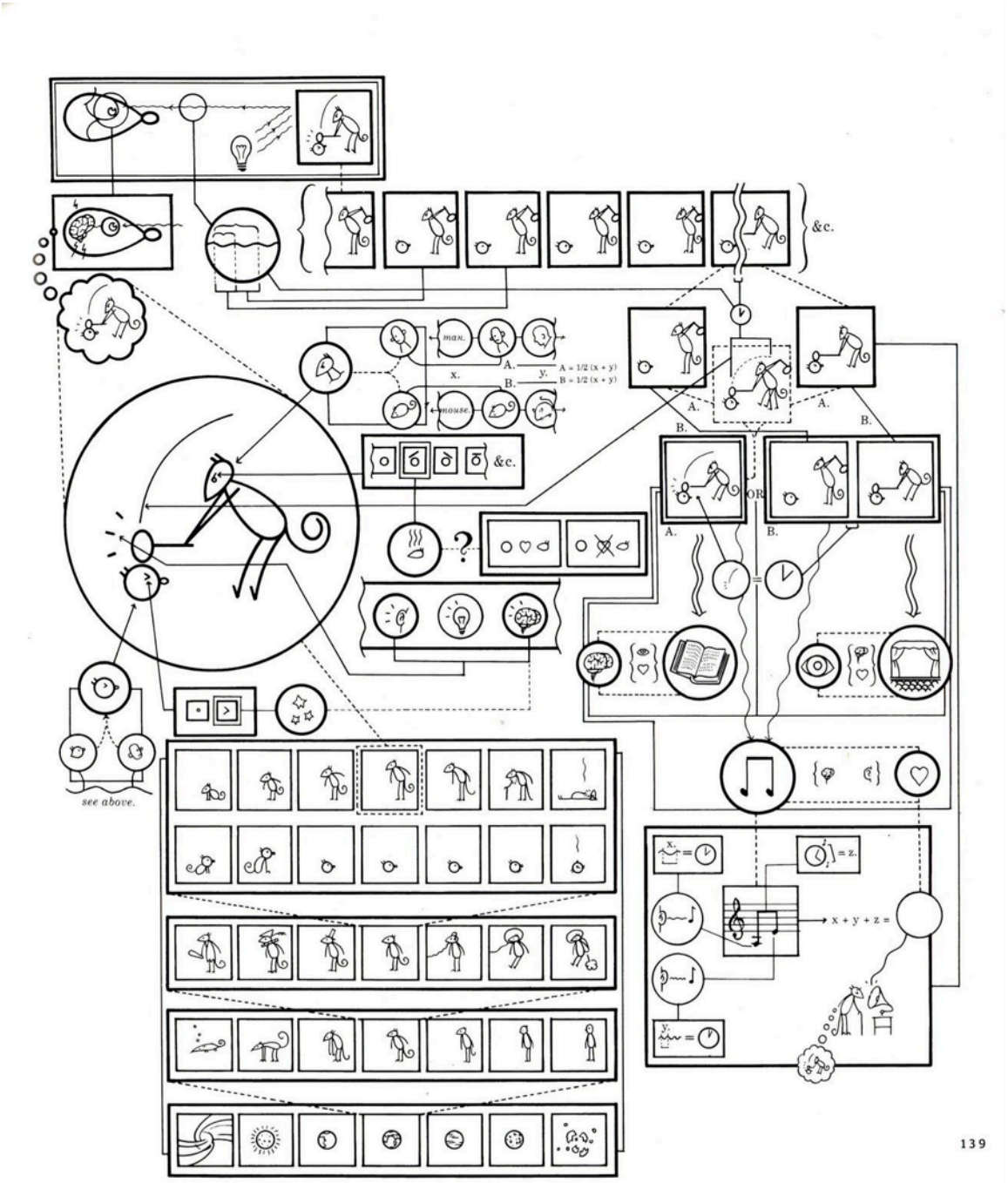

Fig. 9: Chris Ware's Diagram on "graphic language", that not only explains each single line shown in the mainframe, but also – among other things – situates the moment in the history of the cosmos, locates the drawing style between realistic representation and language and shows how sound and time are constructed within the panel. Copyright: Chris Ware/Pantheon

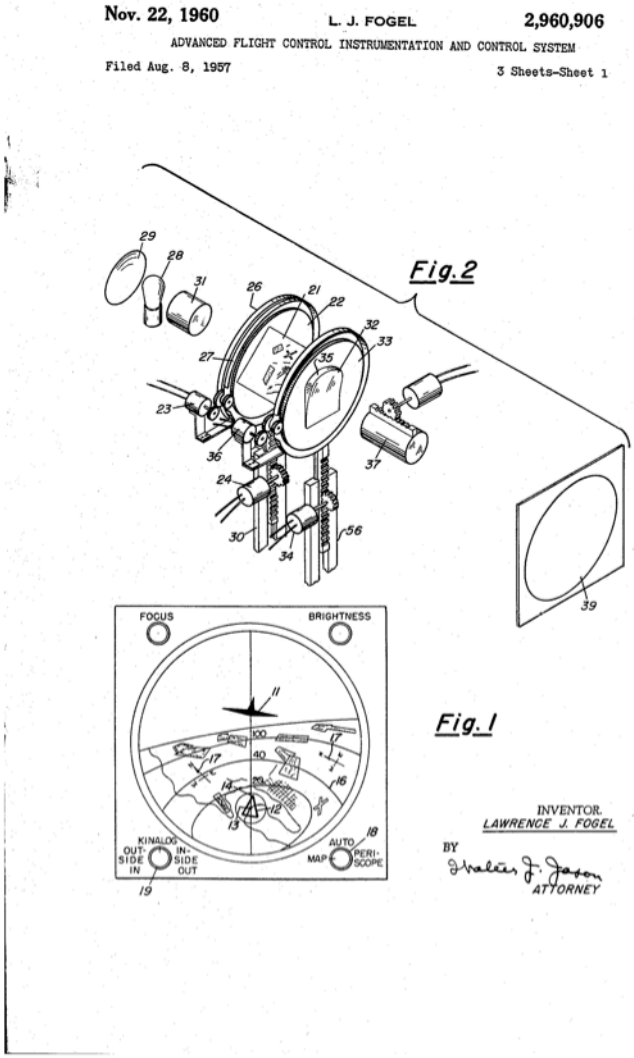

Fig. 10: The Kinalog Display System provides a state of augmentation to the pilot, conveying the orientation or attitude of the aircraft with respect to the earth, which is essential for impaired visibility. Image taken from the patent „Advanced flight control instrumentation and control system US 2960906 A“.

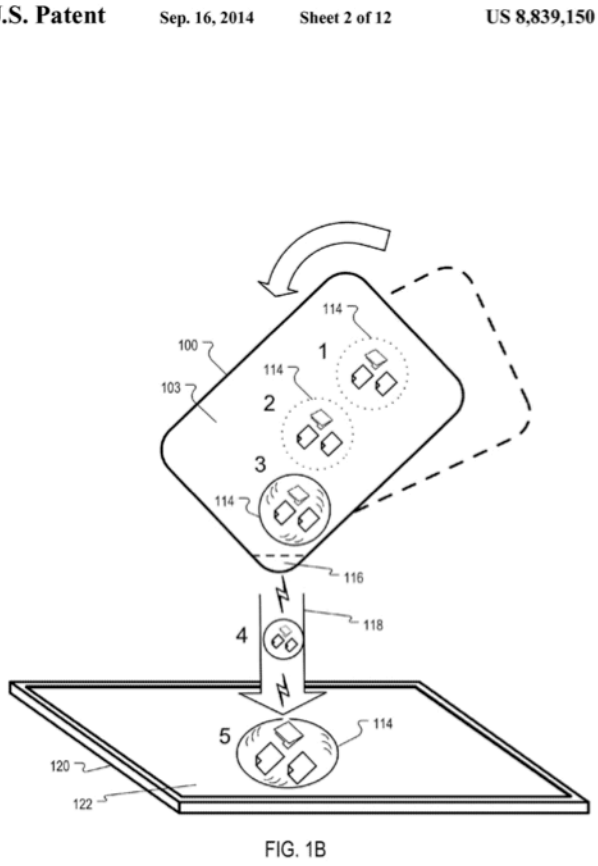

FIG. 1B

Fig. 11: This drawing is taken from a recently registered patent from Apple Inc. and describes the simulation of physical characteristics for files and data. Files can be „poured" like liquid from one device to the other. „Graphical Objects that respond to Touch or Motion Input. US Patent No.: 8,839,150 B2"

References

Card, Stuart K., Mackinlay, Jock D., & Shneiderman, Ben. (1999). *Readings in Information Visualization. Using Vision to Think.* San Francisco: Morgan Kaufmann Publishers.

Cates, Isaac. (2010). Comics and the Grammar of Diagrams. In: M. B. Kuhlmann, D. M. Ball (eds.), *The Comics of Chris Ware. Drawing is a way of Thinking*. Jackson: University Press of Mississippi.

Cheng, Peter C.-H., Lowe, Ric K., & Scaife, Mike. (2001). Cognitive Science Approaches To Understanding Diagrammatic Representations. In: A. Blackwell (ed.), *Thinking with diagrams* (pp. 79-94). Dordrecht, Boston, & London: Kluwer Academic Publishers.

Flusser, Vilém. (2011). *Writing. Does it have a future?*. Minnesota: University of Minnesota Press. English translation see Flusser 1987.

Flusser, Vilém & Bec, Louis. (1989a). *Vampyroteuthis infernalis. Eine Abhandlung samt Befund des Institut Scientifique de Recherche Paranaturaliste*. Göttingen: Immatrix Publications. English translation: (2012). *Vampyroteuthis Infernalis. A Treatise, with a Report by the Institut Scientifique de Recherche Paranaturaliste*. Minnesota: University of Minnesota Press.

Flusser, Vilém. (1985). *Ins Universum der technischen Bilder*. Göttingen: European Photography. English tranlation: (2011). *Into the Universe of Technical Images*. Minnesota: University of Minnesota Press.

Flusser, Vilém. (1987). *Die Schrift. Hat schreiben Zukunft?* [Also available as digital book on two 5,25" floppy disks]. Göttingen: Immatrix Publications. English tranlation: see Flusser 2002.

Flusser, Vilém. (1989b). *Angenommen. Eine Szenenfolge*. Göttingen: Immatrix Publications.

Flusser, Vilém. (1989c). Interviewed by Angelika Stepken, broadcasted on SFB, 21.08.1989. Transcript available at Vilém Flusser Archive.

Flusser, Vilém. (1989d). *Schreiben für Publizieren*. Manuscript for a lecture hold at Karlsruhe Institute of Technology on 02.03.1989. Vilém Flusser Archive, document number 2640.

Hayles, Katherine N. (2009). RFID: Human Agency and Meaning in Information-Intensive Environments. In: *Theory, Culture and Society*. 26 (2-3), 47 – 72.

Hookway, Branden. (2014). *Interface*. Cambridge / London: MIT Press.

Kay, Alan. (1993). The Early History of Smalltalk. *ACM SIGPLAN Notices*, 28 (3), 69-95.

Krämer, Sybille. (2009). Operative Bildlichkeit. Von der 'Grammatologie' zu einer 'Diagrammatologie'? Reflexionen über erkennendes 'Sehen'. In M. Heßler & D. Mersch (Hg.), *Logik des Bildlichen. Zur Kritik der ikonischen Vernunft* (pp. 94-122). Bielefeld: Transcript.

Kuhlen, Rainer. (1991). *Hypertext. Ein nicht-lineares Medium zwischen Buch und Wissensbank*. Berlin & Heidelberg: Springer.

Larkin, Jill H. & Simon, Herbert, A. (1987). Why a Diagram is (Sometimes) Worth Ten Thousand Words. *Cognitive Science*, 11, 65-99.

Link, David. (2010). Scrambling T-R-U-T-H – Rotating Letters as a Material Form of Thought. In S. Zielinski & E. Fürlus (ed.), V*ariantology 4. On Deep Time Relations of Arts, Sciences and Technologies in the Arabic-Islamic World and Beyond* (pp. 215-266). Cologne: Walther König.

Lyotard, Jean-François. (1979). *La Condition postmoderne : rapport sur le savoir*. Paris: Éditions de Minuit. English translation: (1984). *The Postmodern Condition.* Minnesota: University of Minnesota Press.

Nelson, Theodor H. (1984). *Computer Lib: You can and must understand computers now / Dream Machines* [1974]. Michigan: self-published.

Nora, Simon, & Minc, Alain. (1978). *L'informatisation de la société : rapport à M. le Président de la République*. Paris: La Documentation française.

Peirce, Charles S. (1998). *The Essential Peirce: Selected Philosophical Writings Vol. 2* (1895–1913). Edited by the Peirce Edition Project. Bloomington & Indianapolis: Indiana University Press.

Raeburn, Daniel. (2004). *Chris Ware. Monographics.* New Haven: Yale University Press

Rayward, W. Boyd. (1975). *The Universe of Information. The Work of Paul Otlet for Documentation and International Organisation*. Moscow: VINITI.

Russel, Bertrand. (1988). Vagueness. In J. G. Slater (ed.), *The Collected Papers of Bertrand Russell. Vol. 9: Essays on Language, Mind and Matter, 1919–26* (pp. 147-154). London & Boston: Unwin Hyman.

Schmidt-Biggemann, Wilhelm. (1983). *Topica universalis. Eine Modellgeschichte humanistischer und barocker Wissenschaft.* Hamburg: Felix Meiner.

Siegel, Steffen. (2009). *Tabula: Figuren der Ordnung um 1600.* Berlin: Oldenbourg Akademieverlag.

Stjernfelt, Frederik. (2007). *Diagrammatology. An Investigation on the Borderlines of Phenomenology, Ontology, and Semiotics.*

Dordrecht, Heidelberg, London, & New York: Springer.

Ware, Chris. (2000). *Jimmy Corrigan: The smartest Kid on Earth*. New York: Pantheon.

Weigel, Sigrid. (2003). *Genealogy – On the iconography and rhetorics of an epistemological topos*. URL: www.educ.fc.ul.pt/hyper/resources/sweigel [September 1, 2014].

Weiser, Mark, Gold, Rich & Brown, John S. (1999). The Origins of Ubiquitous Computing Research at PARC in the late 1980s. *IBM Systems Journal* 38. 693 – 696.

Wingert, Bernd, Kann man Hypertexte lesen?. (1996). In D. Matejovski & F. Kittler (ed.), *Literatur im Informationszeitalter* (pp. 185-218). Frankfurt/M. & New York: Campus.

Winograd, Terry and Flores, Fernando. (1986). *Understanding Computers and Cognition: A New Foundation for Design*. Norwood NJ: Ablex Publishing.

Zielinski, Siegfried. (2002). *Archäologie der Medien. Zur Tiefenzeit des technischen Hörens und Sehens*. Reinbek: Rowohlt. English translation: (2006). *Deep Time of the Media – Towards an Archaeology of Hearing and Seeing by Technical Means*. Cambridge MA & London: MIT Press.

Zielinski, Siegfried. (2011). *[... nach den Medien]. Nachrichten vom ausgehenden zwanzigsten Jahrhundert*. Berlin: Merve. English translation: (2013). *[… After the Media. News from the Slow-Fading Twentieth Century*. Minnesota: Univocal Publishing.