



Elements of High-Tech

Seminar course

Spring Semester 2023

Thursdays, 15:45–17:30, HIL C 10.2

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Course description

In the 1970s and 80s, high-tech architecture disrupted the international architectural discourse. At the height of the postmodernist craze for “history”, this type of architecture instantiated a devotion to another idol: technology. Never did buildings make visible so much of the latter and in such a bold fashion. Steel nodes, glass walls, polymer roofs: architecture had seemingly turned buildings into machines. However, the very essence of *high-tech* architecture is also the reason which threatens its existence today. Because of their exposed technical details, in fact, many of these buildings need constant care. In addition, since most of these details were (and still are) experimental and custom-made, it is impossible to apply the conventional methods of preservation for their maintenance and refurbishment.

In response to this challenge, this course will examine the elements of high-tech architecture to develop adequate preservation strategies. We will do so in two steps: first, by reviewing a large body of literature on the ontological, epistemological, and social politics of elements and their matter in general. Following this preparatory phase, students will select a high-tech building located in Switzerland and propose ways to refurbish it based on the observation of one of its elements (this may be a steel truss, metal cladding panel, spider bracket, etc). Students successfully completing the course will be able to read high-tech buildings from an object-oriented perspective and devise strategies for their preservation.

Format

This course is broken down in two phases (see “Programme” for the details):

Phase one is a reading seminar. The primary task of this seminar is to read and reflect on texts that present theoretical and architectural positions on “elements” and their preservation. Each of these sessions will feature two back-to-back 50-min discussions on two different texts. All the listed texts are mandatory. The reading load during phase one (2 March – 6 April) amounts to ca 40 pages every other week, so please set aside enough time for the homework.

Phase two is dedicated to the preparation and presentation of the presentations. Students will first form groups of four and select an “element” and a building among the ones listed at the end of the syllabus. Following that, students will book a slot in the course’s google sheets (see link below), put together their project, and present it during the selected session.

Google sheets:

<https://docs.google.com/spreadsheets/d/1z4n8asipkO-Xrf57mIWRFumMGqGNbApLvXvuJ2aS24M/edit?usp=sharing>

The presentation

In each final presentation, students should:

- Outline the key facts about the building (architect, client, location, technology, economics, usage patterns, etc.)
- Focus on one “element” in the building and explain:
 - o how it is made (identify its components, find out facts about its design, manufacturing, and assembly processes, etc)
 - o what it “does” (explain how it determines the design and experience of the building, how it relates to other “elements” in the building, etc)
- Based on these observations, students should make a statement regarding the conservation challenges of the chosen high-tech element and the building in general.

Submissions

At the end of the course, each group should hand in a visual essay (see guidelines under “The Visual Essay”), and a 3D digital model of a construction detail. The modelling process will aid in understanding the construction of the chosen element as well as its production and assembly process. This will help students assess the repairability of the element and make a claim for its preservation. Based on this 3D model, every group should produce one image, illustration, collage or exploded axonometry.

Marking procedure

Student work will be graded according to the standard ETH scale (0-6). In order to get a grade, students are required to:

- Read all the texts, come to class, and actively contribute to the discussions during phase one
- Give one presentation during phase two
- Hand in a 3D digital model and an image of the element / construction detail at the end of the course

Attendance to all sessions is not mandatory. However, more than two unexplained absences will lead to an automatic failure in the course.

Programme

Phase one

23 February	Introduction
2 March	Elements as Images / Machines (Group A-M)
9 March	Elements as Images / Machines (Group N-Z)
16 March	Elements as Actants / Matter (Group A-M)
23 March	<i>No session — seminar week</i>
30 March	Elements as Actants / Matter (Group N-Z)
6 April	Preservation
13 April	<i>No session — Easter</i>

Phase two

20 April	Student presentations
27 April	Student presentations
4 May	Student presentations
11 May	Student presentations

Readings (all mandatory):

PDFs available for download here:

<https://stalder.arch.ethz.ch/seminars/elements-of-hightech-architecture>

2 and 9 March:

Elements as Images

Barthes, Roland. *Mythologies*. New York: Noonday Press, 1972 [1957]

- 35–37 (“Soap-powders and detergents”)
- 53–55 (“Toys”)
- 88–90 (“The New Citröen”)

Baudrillard, Jean. *The System of Objects*. London: Verso, 1996 [1968]

- 22–24 (“Mirrors and Portraits”, “Clocks and Time”)
- 44–45 (“Seats”)
- 93–95 (“Objects and Habits: Wrist-Watches”)

Elements as Machines

Simondon, Gilbert. “Introduction”, “The Abstract Technical Object and the Concrete Technical Object”, and “Hypertely and Self-Conditioning in Technical Evolution”, in *On the Mode of Existence of Technical Objects*. Minneapolis: University of Minnesota Press, 2017 [1958]: 15–21; 25–29; 53–59.

16 and 30 March:

Elements as Actants

Latour, Bruno, “The Berlin Key or How to Do Words with Things”, in Paul Graves-Brown (ed). *Matter, Materiality and Modern Culture*. London: Routledge, 1991: 10-21.

Elements as Matter

Lyotard, Jean-François. “After Six Months of Work... (1984)”, in Hui, Yuk and Broeckmann, Andreas (eds). *30 Years after Les Immatériaux*. Lüneburg: Meson Press, 2015: 29-39.

Hui, Yuk, and Broeckmann, Andreas. “Introduction”. *30 Years after Les Immatériaux*. Lüneburg: Meson Press, 2015: 9–19.

6 April:

Preservation

TBC — readings will be circulated by 30 March

The Visual Essay

Introduction

In literature, “essay” refers to an experimental form. Not by chance, an acceptable translation for “essay” in German is “Versuch”. In that, the essay is first and foremost an experiment in critical thinking in writing. Now, logic suggests that if it is possible to carry out this experimentation through text, it should also be possible to carry it out through other media (like images) or a combination of media (like text and images). Hence the “visual-essay”, an experiment in critical thinking through the combination of text and images.

From a media perspective, translating the essay from the literary to the visual has one effect: the creation of an intermedia order of text and images. But text and images work differently as media. While text requires reading, a decoding process taking place along a linear temporal sequence (think of the importance of syntax in good prose), images allow for the simultaneous processing of several bits of information (think of the visual experience of a collage). This difference makes it clear that experimenting with thinking in language and images follows two different sets of rules.

To create an image essay, the first step is to gather images (images of objects, drawings, sketches, etc), make a selection, and arrange them in a constellation. Once constellated, the images show both their content and relations with other images.

You then proceed by adding a text. If we look at some visual essays from architectural history and architectural journals, it becomes clear that the text can take on different functions. In its most basic form, the text describes the content of the image. A more sophisticated kind of text adds a layer of meaning onto the image by drawing connections between its content and a specific historical fact, object, idea, aesthetic category, type of human experience, etc. Yet another option is a text running parallel to the image as a separate narrative thread. The bottom line is that the interplay of image and text is instrumental in developing an argument.

In the final analysis, the visual essay is an experiment in the interaction of images and text. As such, it is an exercise in critical thinking through the combination of these two elements.

Guidelines

Aim for 15 pictures with a 100-word caption each. Guiding questions for writing a visual essay:

1 – What is the relation between the selected images? Are they arranged in a linear order, are there different reading paths like in a network, or can they be viewed simultaneously? Can the individual image-text sequences be shifted arbitrarily, or are they connected by a common thread that builds on one another and leads to a thesis?

2 - How does the selected image relate to the written text? Does the text simply describe what is in the picture, or does it contain further information? Does the text presuppose specific knowledge of the picture's content?

3 - The selected image is always just a copy of a thing. An original has thus been transferred into a photographic medium. To what extent does the specificity of medium support your thesis?

Examples of visual essays in architectural history

Banham, Reyner. "A Home is Not a House", *Art in America* 2 (1965): 70–79.

Giedion, Sigfried. *Befreites Wohnen: 85 Bilder*. Zurich: Orell Füssli Verlag, 1929.

Gropius, Walter (ed). *Internationale Architektur*, Band 1. München: A Langen, 1925.

Koolhaas, Rem und Bruce Mau (eds). *S, M, L, XL*. New York: Monacelli Press, 1998.

Koolhaas, Rem; Wigley, Mark Bouman, Ole; Inaba, Jeffrey (eds). *Volume 20: Storytelling*. New York: Columbia Books on Architecture and the City, 2009.

Koolhaas, Rem. "The Frontier in the Sky", in: *Delirious New York. A Retroactive Manifesto for Manhattan*. New York: Monacelli Press, 1994 [1978]: 82–87.

Venturi, Robert. *Complexity and Contradiction in Architecture*. New York: The Museum of Modern Art, 1966.

Warburg, Aby; Brink, Claudia; Wanke, Martin (eds). *Der Bilderatlas Mnemosyne*. Berlin: Akademie Verlag, 2000.

Weiss, Daniel. "From the gta Archive", in: Gleich, Moritz and Stalder, Laurent (eds). *gta Papers 1: Architecture/Machine*. Zurich: gta Verlag, 2017: 13-27.

List of “elements”

1. All-glass elevator
2. Escalator
3. Spider bracket
4. Glass panel (float / photochromic / thermochromic)
5. Brise-soleil
6. Polyester membrane
7. Metal cladding panel
8. Steel truss
9. Steel tube
10. Steel node
11. Diagonal brace
12. Cable
13. Air pipe
14. Air vent
15. Paint
16. Glue

List of buildings

1. Theo Hotz Architekten, Briefzentrum Mülligen, Zurich, 1978–85
2. Theo Hotz Architekten, Fernmeldezentrums Herdern, Zurich, 1972–78
3. Fosco-Oppenheimer, Vogt, CLA Institutsgebäude, 1986–98
4. AAA, Immeuble Chauderon, Lausanne, 1970–74
5. Sporthalle Kreuzbleiche, Heinrich Graf, St. Gallen, 1982–84
6. Adolf Wasserfallen, Hallenbad Bläsi, Zurich, 1977–80
7. Theo Hotz Architekten, EMPA, St. Gallen, 1993–96
8. Theo Hotz Architekten, Konferenzgebäude Grünenhof, Zurich, 1991
9. Mario Botta, Raststätte, Piotta, 1993–98
10. Luscher & Linford, Radio-Communication Building EPFL, Ecublens, 1987–94
11. Max Vogt, Wolfgang Jacobson, Beat Conrad, SBB Dienstgebäude, Zurich, 1989
12. Hausammann Architekten, UBS Administration Extension, Biel, 1993–96
13. Jean Nouvel, Emmanuel Cattani Partner, KKL, Luzern, 1989–2000
14. Richard Brosi und Obrist, Busbahnhof Chur, 1985–93
15. Grimshaw Partners, Zurich Airport, 2004
16. Jean Nouvel, Cartier distribution centre, Fribourg, 1994
17. Artevetro Architekten AG, Felix Knobel, The Eyecatcher Building, Basel, 1998
18. Suter + Suter, Ciba Klybeck Canteen, Basel, 1968

All-glass elevator

Bernard, Andreas. *Die Geschichte des Fahrstuhls: über einen beweglichen Ort der Moderne*. Frankfurt am Main: Fischer, 2006.

Cogley, Bridget. "Great glass elevator to whisk visitors 83-storeys up Chicago's Aon Center", *dezeen*. 28. March 2019. <https://www.dezeen.com/2019/03/28/great-glass-elevator-aon-center-chicago-solomon-cordwell-buenz/>.

Elevators. High-Rise Solutions. *TKE* (n.d.) <https://www.tkelevator.com/us-en/products/elevators/high-rise-solutions/>.

Glancey, Jonathan. "Going up: How the elevator changed everything", *BBC Culture*. 21.10.2014. <https://www.bbc.com/culture/article/20140819-how-the-lift-changed-everything>.

Hartwig, Lutz et al., eds. *Vertikal: Aufzug, Fahrtreppe, Paternoster: Eine Kulturgeschichte vom Vertikal-Transport*. Berlin: Ernst & Sohn, 1994.

Keane, Katharine. "Calling all Adrenaline Junkies." *Architect* 108.5 (2019): 18.

Koolhaas, Rem et al., eds. *Elevator*. Venice: Marsilio, 2014.

Paumgarten, Nick. "Up and then down. The lives of elevators." *The New Yorker*. 21. April 2008. <http://users.clas.ufl.edu/burt/spaceshotsairheads/elevators.pdf>.

Pesch, Berthold. "Elevating Berlin. Glass Lift Architecture for the German Parliament." *Elevator Technology* 10 (2000): 100–107.

Simmen, Jeannot and Uwe Drepper. *Der Fahrstuhl: Die Geschichte der vertikalen Eroberung*. München: Prestel, 1985.

Strakosch, George R., ed. *The Vertical Transportation Handbook*. New York: Wiley, 1998.

Escalator

Carpenter, Megan. "How the Escalator Forever Changed Our Sense of Space», *Smithsonian Magazine*. 27 June 2019. <https://www.smithsonianmag.com/innovation/how-escalator-forever-changed-our-sense-space-180972468/#:~:text=Elevators%2ohave%2oa%2ounique%2C%2oprecise,into%2ospace%2oabove%2oand%2obelow>.

Dennis, Richard. "The Architecture of Hurry", in: *Cityscapes in History: Creating the Urban Experience*. Edited by Katrina Gulliver and Heléna Totheds. Farnham: Ashgate, 2014: 133–135.

Elliott, Cecil D, *Technics and Architecture*, Cambridge: MIT Press, 1998: 330–342 and 327–361.

Jameson, Fredric. "The Cultural Logic of Late Capitalism." *Rethinking Architecture: A Reader in Cultural Theory*. Edited by Neil Leach. London: Routledge, 1997: 229–31.

Koolhaas, Rem and Irma Boom. eds. *Escalator*. Venice: Marsilio, 2014.

Waters, Dan. "A Stroll up the Hong Kong Mid-Levels Escalator with a Few Digressions along the Way". *Journal of the Royal Asiatic Society Hong Kong Branch* 53 (2013): 263–284.

Weiss, Srdjan Jovanovic and Sze Tsung Leong, *Harvard Shopping Guide: Escalator*, Köln: Taschen 2001. <https://www.oma.com/publications/project-on-the-city-ii-the-harvard-guide-to-shopping>

Zacharias, John and Richard Ling, "Choosing Between Stairs and Escalator in Shopping Centers: The Impact of Location, Height, and Pedestrian Volume", *Environment and Behavior* 47.6 (2014): 694–709.

Zacharias, John. "The Central–Mid-levels Escalator as Urban Regenerator in Hong Kong", *Journal of Urban Design* 18.4 (2013): 583–593.

Spider bracket

Barry, Kevin. *Traces of Peter Rice*, Dublin: Lilliput Press, 2012.

Boake, Terri Meyer. *Understanding Steel Design: An Architectural Design Manual*, Birkhäuser: Basel 2012: 183–195.

Brookes, A. J. and C. Grech, *Connections*, London: Butterworth-Heinemann, 1992.

Eekhout, Mick. *Lectures on Innovation in Building Technology*, Amsterdam: IOS Press, 2016.

Khoraskani, Roham Afghani. *Advanced Connection Systems for Architectural Glazing*, Cham: Springer, 2015: 33–52.

Nijssen, Rob. *Glass in Structures*, Basel: Birkhäuser, 2003.

Patterson, Mic. *Structural Glass Facades and Enclosures*, London: Wiley, 2011.

Rice, Peter and Hugh Dutton. *Structural Glass*, London: E&FN Spon, 1995.

Rice, Peter. *An Engineer Imagines*, London: Batsford, 2017.

Glass panel (float / photochromic / thermochromic)

“An Architect Who Revolutionised Glass in Architecture”, *Pilkington*. 11 Apr 2014.
<https://www.pilkington.com/en-gb/uk/news-insights/archived-blogs/an-architect-who-revolutionised-glass-in-architecture#>.

Bell, Michael and Jeannie Kim. *Engineered Transparency: The Technical, Visual, and Spatial Effects of Glass*, Princeton: Princeton Architectural Press, 2009.

Bricknell, David J. *Float. Pilkingtons' Glass Revolution*. Lancaster: Crucible, 2009: 1–11 and 40–55.

Cable, Michael. “Mechanization of Glass Manufacture.” *Journal of the American Ceramics Society* 82 (1999): 1093–1112.

Eskilson, Stephen. *The Age of Glass: A Cultural History of Glass in Modern and Contemporary Architecture*. London: Bloomsbury Publishing, 2018.

Neugebauer, Jürgen. “Applications for Curved Glass in Buildings”. 1 Jan. 2014: 67–83.

Pawley, Martin. “Structures supplement.” *Building Design* 943 (1989): 5–45.

Persson, Rune. *Flat Glass Technology*. New York: Springer, 2013.

Ritchie, Ian. “Aesthetics in Glass Structures”, *Structural Engineering International* 14.2 (2004): 73–75.

Schnapp, Jeffrey T. “Crystalline Bodies: Fragments of a Cultural History of Glass,” *West 86th* 20.2 (2013): 173–194.

Stacey, Michael. “Maximum vision.” *Habitat International* 14.2-3 (1990): 227–233.

Brise-soleil

Barber, Daniel. “Le Corbusier, the Brise-Soleil, and the Socio-Climatic Project of Modern Architecture, 1929-1963” *Thresholds* 40 (2012): 21–32.

Da Cunha, Eduardo Grala. "Myths and truths about the brise-soleil: From aesthetics to energy efficiency." *Arquitetura revista* 7.1 (2011): 73.

Le Corbusier. *Problèmes de l'ensoleillement: le brise soleil*. Paris: Éclairage, 1946.

Mandalaki, Maria and Theocharis Tsoutsos. *Solar Shading Systems: Design, Performance, and Integrated Photovoltaics*. Berlin: Springer, 2020.

Olgyay A, Olgyay V. *Solar control and shading devices*. New Jersey: Princeton University Press, 1957.

Siret, Daniel. "Généalogie du brise-soleil dans l'œuvre de Le Corbusier." *Cahiers thématiques* 4 (2004): 169–181.

Polyester membrane

Ciampi, Giovanni. "Energy performance of PVC-Coated polyester fabric as novel material for the building envelope: Model validation and a refurbishment case study". *Journal of Building Engineering* 41 (2021): 102437.

Drew, Philip. *Tensile Architecture*. London: Routledge, Taylor & Francis Group, 2019.

Zheng, Jian Jun. "Trends in Building Materials Research". *Advanced Materials Research* 5 (2012): 450-451.

Metal cladding panel

Anon. "Design by cooperation – metal panel cladding". *Architects' Journal* 191.4 (1990): 61–65.

Brookes, Alan J. "Composite metal panels, design and manufacture." *Architects' Journal* 194.12 (1991): 53–56.

Brookes, Alan J. and C. Grech. *Building Envelope*. London: Butterworth-Heinemann, 1990.

Brookes, Alan J. and M. Stacey. "Cladding – product review" *AJ Focus, Architects' Journal* July (1991): 29–50.

Brookes, Alan J. and M. Stacey. "Cladding – product review" *AJ Focus, Architects' Journal* October (1992): 25–32.

Brookes, Alan J. and M. Stacey. "Cladding – product review" *AJ Focus, Architects' Journal* December (1993): 15–25.

Brookes, Alan J. and Maarten Meijs. *Formed Metal Including Profiled Metal and Sheet Metal, Composite Metal Panels and Rain Screens*. London: Routledge, 2008: 90–145.

Brookes, Alan J. *Concepts in Cladding*. London: Construction Press, 1985.

Foster, Norman. "Frontiers of design." in: *Norman Foster Associates*. Edited by I. Lambot, Hong Kong: Watermark, 1978: 127.

Murphy, J. "Skin deep, technics for external wall panels." *Progressive Architecture* 2 (1978): 83–91.

Thorogood, R. "Metal Skinned Sandwich Panels for External Walls", *BRE CP6/79*. Garston: Building Research Establishment Press, 1979.

Watts, Andrew. *Modern Construction Handbook*. Wien: Springer, 2001.

Steel truss

Addis, Bill. "The Crystal Palace and its Place in Structural History." *International Journal of Space Structures* 21.1 (2006): 3–19.

Baweja, Vandana. "Stainless Steel in Architecture." *Architecture + Design* 14.4 (1997): 112.

Blanc, Alan et al. eds. *Architecture and Construction in Steel*. London: Taylor & Francis, 1993.

Campos, Ines D.D. and Luis F.A. Bernardo. "Architecture and Steel. Reflection and Analysis on the Use of Steel Structures (in Sight) as a Concept in the History of Architecture." *Designs* 4.3 (2020): 30.

Giedion, Sigfried. "Iron", in: Sigfried Giedion, *Building in France. Building in Iron, Building in Ferroconcrete*, Santa Monica: Getty Center, 1995: 100–150.

Krause, Joachim. 'Ephemerisierung. Wahrnehmung und Konstruktion'. *Wahrnehmung und Geschichte. Markierungen zur Aisthesis materialis*. Edited by Bernhard J. Dotzler and Ernst Müller. Berlin: Akademie Verlag, 1995: 135–163.

Macdonald, Angus. "The Aestheticisation of the Steel Framework: The Contribution of Engineering to a Strand of Modern Architecture That Became Known as High Tech." *Proceedings of the Second International Congress on Construction History. The Construction History Society*. Cambridge, 2006.

Makowski, Zygmunt Stanislaw. "Space frames and trusses." *Constructional Steel Design. An International Guide*. London: Elsevier, 1992: 791–843.

Steel tube

Arnheim, Rudolf et al. "Inside and Outside in Architecture: A Symposium." *The Journal of Aesthetics and Art Criticism* 25.1 (1966): 3–7.

Kaika, Maria & Erik Swyngedouw. "Fetishizing the modern City: The Phantasmagoria of Urban Technological Networks." *International Journal of Urban and Regional Research* 24.1 (2000): 120–138.

Kloiber, L. A. "Designing Architecturally Exposed Steel Tubes." *Modern Steel Construction* 33.3 (1993): 30–38.

Larkin, Brian. "The politics and poetics of infrastructure." *Annual Review of Anthropology* 42.1 (2013): 327–343.

Roscher, Harald and Ulf Helbig. 'Historische Entwicklung der Rohrleitungstechnik' *Rohrleitungen*. Edited by: H.B. Horlacher and U. Helbig. Berlin: Springer, 2015.

Schlaich, J. and H. Schober. "Steel castings in architecture and engineering." *Advances in Construction Materials* Edited by C.U. Grosse. Berlin: Springer, 2007: n.p.

Steel node

Brookes, Alan J. & Grech, Chris. *Konstruktive Lösungen in der High-Tech-Architektur*. Basel: Birkhäuser, 1991.

Brookes, Alan J. and Chris Grech. *Das Detail in der High-Tech-Architektur*. Basel: Birkhäuser, 1991.

De Oliveira, J.C. et al. "Cast steel nodes in tubular construction—Canadian experience." *Tubular Structures XI*. Edited by J.A. Packer and S. Willibald. Milton Park: Routledge, 2017: 523–529.

n.A. 'Standardisierung im Metallbau'. *ARCH+* (n.d.): 116–123.
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Ochshorn, Jonathan. "Connections", in: Jonathan Ochshorn. *Structural elements for architects and builders. Design of Columns, Beams, and Tension Elements in Wood, Steel, and Reinforced Concrete*. Oxford: Butterworth-Heinemann, 2009.

Schober, Hans. "Steel Castings in Architecture and Engineering." *Modern Steel Construction* 43.4 (2003): 65–72.

Diagonal brace

Boake, Terri Meyer. "Diagrids, the New Stability System: Combining Architecture with Engineering." *AEI 2013: Building Solutions for Architectural Engineering* (2013): 574–583.

Clough, Ray W. and Victor A. Jenschke. "The effect of diagonal bracing on the earthquake performance of a steel frame building." *Bulletin of the Seismological Society of America* 53.2 (1963): 389–401.

Makowski, Zygmunt Stanislaw. *Steel space structures*. London: M. Joseph, 1965.

Cable

Asendorf, Christoph. 'Die Linie' and 'Durchaderung', in: Christoph Asendorf. *Ströme und Strahlen. Das langsame Verschwinden der Materie um 1900*. Giessen: Anabas, 1989: 58–64 and 85–95.

Black, Robert Monro. *The History of Electric Wires and Cables*. London: Science Museum London, 1983.

Gethmann, Daniel and Florian Sprenger. *Die Enden des Kabels. Kleine Mediengeschichte der Übertragung*, Berlin: Kadmos, 2014: 7–38 and 104–116.

Harwood, John. "On Wires – or: Metals and Modernity Reconsidered." *Grey Room* 69 (2017): 108–136.

Isenstadt, Sandy. *Electric Light: An Architectural History*. Cambridge: MIT Press, 2018.

Schivelbusch, Wolfgang. *Disenchanted Night: The Industrialization of Light in the Nineteenth Century*. Oakland: University of California Press, 1995.

Air pipe

Asendorf, Christoph. 'Leitungsnetze', in: Christoph Asendorf. *Ströme und Strahlen. Das langsame Verschwinden der Materie um 1900*. Giessen: Anabas, 1989: 58–73.

Banham, Reyner. "Exposed Power". in: Reyner Banham, *Architecture of the Well-Tempered Environment*. London: Architectural Press, 1984: 234–265.

Gleich, Moritz. "From Storage to Transmission. Architecture and the Communication of Heat", in: *Perspecta. The Yale Architectural Journal* 50 (2018): 199–213.

Lauchlan, C. et al. "Air in pipelines – a literature review." *Technical Report*. Wallingford: HR Wallingford, 2005.

Lewis, Rodney H. "Heating and Air-conditioning Systems – A historical overview and evolution" *CONF-950104: American Society of Heating, Refrigerating and Air-Conditioning Engineers*, 1995.

Air vent

Awbi, Hazim B. *Ventilation of buildings*. Routledge, 2002.

Böer, Wulf. "Synthetic Air." *Future Anterior: Journal of Historic Preservation, History, Theory, and Criticism* 13.2 (2016): 77–101.

Burgess, William A. et al. *Ventilation for control of the work environment*. Hoboken: John Wiley & Sons, 2004.

Horn, Eva. "Air as Medium." *Grey Room* 73 (Fall 2018): 6–25.

Horn, Eva. "Air Conditioning: Taming the Climate as a Dream of Civilization", in: *Climates: Architecture and the Planetary Imaginary*. Edited by James Graham, New York: Lars Müller, 2016: 233–243.

McQuiston, Faye C. et al. *Heating, Ventilating, and Air Conditioning: Analysis and Design*. Hoboken: John Wiley & Sons, 2004.

Sloterdijk, Peter. "Air/Condition." In: Peter Sloterdijk. *Sphären III: Schäume*. Frankfurt am Main: Suhrkamp, 2004: 154–191.

Paint

Armstrong, Graham. "Protection and colour for architectural metal." *Anti-Corrosion Methods and Materials* 32.2 (1985): 7–8.

Birren, Faber. "Functional Color and the Architect." *Journal of the American Institute of Architects* 10.6 (1949): 265–268. <https://usmodernist.org/AJ/AJ-1949-06.pdf>

Blaszczyk, Regina Lee. "Mood Conditioning" und "Conclusion", in: Regina Lee Blaszczyk. *The Color Revolution*, Cambridge: MIT Press, 2012: 215–241 and 289–298.

Mottram, Judith and Tom Jefferies. "Color in the designed environment." Edited by Marilyn DeLong and Barbara Martinson, *Color and Design*, London: Berg Publishers, 2012: 18–35.

Rüegg, Arthur. "Colour Concepts and Colour Scales in Modernism." *Daidalos* 51 (1994): 66–77.

Serra, Juan and Angela Garcia Codoner. "Color composition in postmodern western architecture", *Color. Research and Application* 39.4 (2014): 399–412.

Simeone, Luca. "Color as a New Skin: Technology and Personalization." Edited by Marilyn DeLong and Barbara Martinson, *Color and Design*, London: Berg Publishers, 2012: S.215–224.

Glue

Bartels, Waldemar. *Klebstoffe. Separatdruck aus der Dokumentation Holz*. Zurich: Lignum, 1960.

Lynn, Greg, "Chemical Architecture", *Log* 23 (Fall 2011): 27–29.

Industrieverband Klebstoffe. *Auf der Höhe der Zeit. 70 Jahre Industrieverband Klebstoffe*. Wiesbaden: Springer Vieweg, 2017.

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