Designing Sensual Spaces: Integration of Spatial Flows Beyond the Visual

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Designing Sensual Spaces: Integration of Spatial Flows Beyond the Visual

Abstract
Architectural design is an intellectual process which mediates between the hand and the eye to produce visual images for communication of spatial properties. Space and its composition are usually depicted by drafting a geometrically constructed image of material limits. These types of drawings usually do not communicate anything about spatial behavior, performance or experience. They communicate the physical boundaries but not the behavioral content of space, which is air--its movement patterns, temperatures and odors. Spatial continuity is furthermore dissected through orthographic projection, which dismembers a whole into parts. But corners are as essential to spatial experience as is the behavioral qualities of air. With very few exceptions architectural design practices most often still operate within a tradition of pure form and pure space, which are shaped as a balance of aesthetics and function.

New computational tools like computational fluid dynamics (CFD), which were developed to simulate spatial behavior of non-visual phenomena, could integrate the knowledge of other sensual experiences and perceptions beyond the visual into the design practice. But various questions arise related to architectural design practices. How close are those abstractions to 'real' spatial experiences? And how feasible is the integration of such tools into the design process to date? What alternatives do architects have to integrate the non-visual into architectural representation?

This paper will thus address possibilities to restructure the relationship between design practices and environmental forces like heat transfer and air movement, with the goal of developing a better understanding of how to integrate natural air and energy flows into architectural design representation and thus into the design itself. New methods of representation are necessary for a renewed understanding of space that addresses all senses. The design principles which are highlighted are representation, visualization and simulation of space and its boundaries or boundary condition. Using examples from design research and design pedagogy, the paper also contributes to the ongoing debate about sensual culture and challenges a purely visual reception and perception of the world we live in and design for. Reality is also tactile, thermal and olfactory.

Keywords
Architecture, Visualization, Five Senses, Spatial Comfort, Thermal Behavior

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Designing Sensual Spaces: Integration of Spatial Flows Beyond the Visual

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Abstract: Architectural design is an intellectual process which mediates between the hand and the eye to produce visual images for communication of spatial properties. Space and its composition are usually depicted by drafting a geometrically constructed image of material limits. These types of drawings usually do not communicate anything about spatial behavior, performance or experience. They communicate the physical boundaries but not the behavioral content of space, which is air--its movement patterns, temperatures and odors. Spatial continuity is furthermore dissected through orthographic projection, which dismembers a whole into parts. But corners are as essential to spatial experience as is the behavioral qualities of air. With very few exceptions architectural design practices most often still operate within a tradition of pure form and pure space, which are shaped as a balance of aesthetics and function. New computational tools like computational fluid dynamics (CFD), which were developed to simulate spatial behavior of non-visual phenomena, could integrate the knowledge of other sensual experiences and perceptions beyond the visual into the design practice. But various questions arise related to architectural design practices. How close are those abstractions to ‘real’ spatial experiences? And how feasible is the integration of such tools into the design process to date? What alternatives do architects have to integrate the non-visual into architectural representation? This paper will thus address possibilities to restructure the relationship between design practices and environmental forces like heat transfer and air movement, with the goal of developing a better understanding of how to integrate natural air and energy flows into architectural design representation and thus into the design itself. New methods of representation are necessary for a renewed understanding of space that addresses all senses. The design principles which are highlighted are representation, visualization and simulation of space and its boundaries or boundary condition. Using examples from design research and design pedagogy, the paper also contributes to the ongoing debate about sensual culture and challenges a purely visual reception and perception of the world we live in and design for. Reality is also tactile, thermal and olfactory.

Keywords: Architecture, Visualization, Five Senses, Spatial Comfort, Thermal Behavior

Figure 1: Architectural Model for a University Building Developed Around Ventilation and Circulation Spaces; Unbuilt Project by Passe Kaelber Architects, Berlin 1997. (Photo: Passe Kaelber Architects)
Representation of the Boundaries of Space: Visual versus Aerial Phenomena

One reason for the discrepancy between the design of architectural shape or form and its thermal, olfactory and sensual content is the dominance of an exclusively visual design culture related to absolute space and its conventional depiction using descriptive geometry.

“Air has traditionally been, not the antagonist of the building, but its unobserved complement. Buildings, like utterances, are articulations of the air. No structure that contained no space, had no cavity in it, could qualify as a building. And yet, though buildings include, enclose and admit air, that air is not thought of as belonging to the building.”

Following Gaston Bachelard’s ‘Poetics of Space’ Steven Connor\(^2\) also distinguishes between two different means of spatial creation: a space created by the hollowing out of a volume through a body in motion or a projection of a geometric entity into the continuous space by cutting it out. “The manner of a burrow or abode brings space into being as a form of habitat; the other demarcates a space by withdrawing it from a larger space.”\(^3\) When an architect draws the line of a wall along a geometric projection, this line becomes the demarcation line between inside and outside. Following the movement of the hand with a line on the paper could be related to the experiential content of space not only its physical boundaries. The thermal image of an infrared camera reveals that the boundaries are truly blurred when heat is transitioning between and through a solid surface.

Figure 2: Beginning Design Studio Model Resembling Bachelard’s Burrow, Technical University Berlin 1997 (Photo: Ulrike Passe)

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3 __. p. 120
Michelle Addington points out in “The phenomenon of the non-visual” that the representation of air movement has not changed very much over the course of the last hundred years. Directional movement is indicated by lines with an arrow at the front. This is not depicting the actual physical event, because there is not line in the air. Air, sound and heat move in spherical volumetric plumes of pressure difference, which are only diagrammed with those lines. So far conventional orthogonal projection is used, which again dissect the volumetric entity of spatial expansion. Thus better methods of representing these physical phenomena still have to be rediscovered.

The Sixth Sense – Thermal Comfort

Generally speaking, a ‘sense’ is understood as “any of the faculties by which the mind receives information about the external world or about the state of the body. In addition to the traditional five faculties sight, hearing, touch, taste and smell, the term includes the means by which bodily position, temperature, pain, balance are perceived”.

The thermal sense is usually addressed in architecture through design decision-making processes guided by prescriptive quantitative performance standards. Since the discipline lacks the tools to represent the related spatial quality, temperature and thermal experience of a space is not represented or sculpted in most design drawings and models but is fulfilled in a separate set of the engineering calculations.

The term human comfort only developed with the rise of air conditioning, when it was possible to create artificial weather. At that time, it became important to research which conditions actually were desirable. Human comfort is calculated for still air, disregarding the moving air necessary for natural ventilation which enhances rather than restricts human comfort. Air quantified for thermal comfort is neutral: no smell, no air movement, 50% humidity, mean radiant temperature is equal to air temperature, the human activity is assumed to be sedentary, with no special behavior or clothing.

The conceptual framework of air within a space has not always been this static and it cannot continue to be that static if architects would like to embrace passive cooling and natural ventilation techniques. Steven Connor has pointed back to Vitruvius Vth book, which describes in great detail how the space of the Greek theater acts as a lung preventing stale air from hanging out around the spectators and allows air circulation for cooling effects. Air in Modern space is considered static, air in classic and pre-seventeenth century space was always moving, animating a building.

Thus it becomes clear that current architectural production is dominated by the visual sense and static, neutral air. Comfort, pleasure and delight are not governed by visual perception alone but by temperature, humidity, air, odors, sound and other environmental forces. Other sensual experiences, such as the thermal or acoustic, play a large role in why occupants accept or reject certain spaces.

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Modernity and the Priority of the Visual over Other Senses

Perception of modern space as an expression of the Modern age was and often still is reduced to a matter of visual aesthetics. Architects, theoreticians, and critics all address modern buildings as exclusively visual phenomenon. For example, Giedion, in ‘Space, Time, Architecture’ hardly mentions the importance of environmental conditions at all. Laszlo Moholy Nagy, an important protagonist of the Modern Movement argued for the development of a new approach to space, calling for the ‘The New Vision’ of space-in-motion, a purely visual device, leaving the rest of environmental design issues to be addressed by machines. Although Le Corbusier postulates the ‘living machine’, Beatriz Colomina realized a contradiction in his work. She indicated in her analysis “Windows” that Le Corbusier’s separation of vision from all other environmental forces (and senses) can be seen as one reason for the ‘placelessness of modern man,’ an essential concept of the Modern Movement. The liberation of vision and space from the limitations of building mass and historical styles was facilitated by the potential for absolute control of the thermal environment and related energy flows.

The dominance of form over content and quality in contemporary architecture is supported and paralleled by domination of the visual over all other senses: tactile, audio, smell, taste and thermal experiences. Buildings are usually designed to provide a neutral response to the ‘lower’ senses. As conceived of by the Gestalt theory in the Nineteenth century, modern space perception is strongly considered a matter of visual aesthetics. Thermal conditions have long been neglected and thus the control systems for environmental forces have been deliberately separated from space and vision. Only a few critics, historians or theoreticians like Reyner Banham reminded the architectural community that space, culture and environmental forces are related. His history of environmental systems pointed to the fact that space has a fluent, changing quality.

In order to achieve a homogenous interior thermal condition air in most contemporary and Modern spaces in not allowed to move and expand freely, but is channeled and pressed through ductwork, which causes friction and requires fans and energy to get it moving only to be exhausted or exhaled through chimneys.

Exceptions: Climate Art

‘Climate Art’ in early Modernism, the 60s and today show that the curiosity to explore and distort conventional perception went far beyond the visual and extended to smell, thermal comfort and tactility using the mechanical ventilator as an experimental tool in the same manner in which others had used the camera. These projects on the boundary between archi-

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tectural investigation and artistic expression have refrained from cutting out space along a Cartesian gridline from a larger whole to condition its interior. Instead some particular projects briefly described below have found ways to manipulate thermal conditions without the need of fixed physical enclosures.

Early Futurist performances, which experimented with temperatures and ventilators at the beginning of the 20th century set the precedents for Yves Klein’s “Architecture of Air” developed between 1958 and the early 60s. This project might have acted as a role model for the ‘Blur Building’ by Diller and Scofidio, designed and built for the Switzerland Expo 02. These and other art installations often provide an innovative approach to the experiences of airflow, climate and weather, far more often than architecture. While the interest of Futurists like Marinetti lay in an exploration of the extremes of human thermal environment, by stretching the boundaries of what was bearable those works led to a fascination in the 1960’s with the homogeneity of interior atmosphere and climate and the possibility of creating such steady conditions.

Yves Klein’s ‘Architecture of Air’ deserves a special recognition in this genealogy of ideas because he actually proposed an extreme utopian city freed of all physical boundaries, conditioned only by a roof of air. He even conducted physical experiments, but after serious discussions with an air-conditioning firm in Hamburg, Klein realized that this idea was not technologically possible at the time. More recently, Diller and Scofidio’s “Cloud” or “Blur Building” presented a miniature version of an artificial climate in a more playful manner. The New York based team created an artificial fog by spraying droplets of moisture at high pressure into the air above a steel structure situated in Lac Neufchatel. The cloud moved up when temperatures rose and sideways with the wind. The installation took advantage of the physics of air and specifically the psychometric chart which diagrams the relationship of relative humidity and dew point and indicates that warm air can hold more moisture than cold air.

The main achievements of all three projects were the creation of a spatial experience without the erection of a physical boundary and the demonstration that spatial composition can enhance thermal experience. Appreciating these effects is crucial to the contemporary rediscovery of passive strategies for heating, cooling and ventilation. It is new territory for design processes dominated by form and for architectural concepts which consider control systems for thermal conditions separate from space and vision. Thus art installations can create awareness of the potentials which lie in the complexity of atmospheric qualities of space and air. These art installations and critical works of architecture take extreme positions because they enhance or distort human comfort experience related to moving air beyond the established norm and highlight awareness of immaterial, non visual, yet experiential phenomena of spaces filled with surprises, delight.

Such ephemeral events are usually not perceived as part of the scope of architects. On the contrary, thermal comfort of interior space is defined as homogenous satisfaction or neutral sensation and hardly questioned as a design parameter. Often the creation of interior comfort is thus left to the devices of mechanical systems instead of an enhancement of natural flows. It is not a coincidence that the aforementioned projects were paralleled by a broad introduction

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of mechanical systems into residential and commercial buildings during the past century. Architecture is still bound to a homogenous understanding of indoor thermal comfort, which derived from a desire to control the indoor environment through the mechanization of its thermal condition. Architecture, which shapes air to enhance comfort, has had no place in the critical discourse and is only marginally addressed in the design practice. Lisa Heschong’s ‘Thermal Delight in Architecture’¹⁷ is an exception in this discourse because it addresses the delight of diverse temperature experiences.

Although intuitively achieved for centuries through observation and experience, essential qualities of architecture related to natural ventilation flows which are modulated by spatial composition have been absent in designs of the recent past. They did not conform to the prevailing measurable, standardized understanding of comfort.

Figure 3: Ventilation Opening in Alvar Aalto’s Own House (1932); Photo: Ulrike Passe 2005

Eye – Hand - Skin Phenomenology – Five Senses

Merleau Ponty’s very influential ‘Phenomenology of Perception,’¹⁸ which started out as a critique of the scientific world view, is itself now under criticism by Michel Serres as focusing too singularly on the visual sense and on language as the main means of expression, while not addressing the ‘lower senses’. Michel Serres thus responds to Merleau Ponty with the

'Five Senses',¹⁹ which is only now (2009) translated into English. Serres reinstall the skin as the place of the soul and the main sense with which humans experience their environment. The skin places the user into the space, the eye detaches the user from the space and space is neither neutral nor empty, it contains air and, as much as engineers have tried to control it, air always has a particular smell and odor.

**Drawing Boundary Conditions – Sensing the Immaterial**

Michelle Addington²⁰ remarks that architects too often consider the boundary as a fixed object instead of as a point of transfer and transition. The study of building science more and more reveals the physical fact that no part of the building is solid but porous and affected by vapor diffusion, heat conduction and convection. Properties of matter are a consequence of particle movement due to temperature and pressure difference, infiltration, vibration etc. Those physical phenomena contribute to the character of a building, but cannot be represented.

The depiction of motion in drawings has the potential of taking on many forms while utilizing manifold materials and tools. The water color design drawing used layers of the capillary flow of water enriched with pigments to visualize the diffused aura of spatial boundaries. Matthias Sauerbruch and his research group dedicated 1995-97 two years of undergraduate education at the Technical University Berlin to design research into the nature of boundary and limits in architectural production and representation²¹. The group of faculty and students worked on the topics of embodied edges, inhabited borders, oscillating territories, fluid limits and catalytic borders to develop space which transgresses boundaries.

![Image](image_url)  

Figure 4: Design Studio Water Color Depicting Movement; Undergraduate Design Education at the Technical University Berlin, 1996; Photo: Ulrike Passe

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Fluid Motion - Still Motion

Visiting Villa Lante, the visitor instantly becomes aware of the relationship of form and flow. The water basins in the elaborate hillside garden are shaped to enhance and facilitate certain flow patterns and sounds of water: from fast and agitated to slow, calm and even still. Motion and form in fluent matter are intrinsically related and are drawn into the landscape for entertainment and pleasure.

Figure 5: Two Water Features Giardino di Villa Lante; Photo: Ulrike Passe, 2007

Simulation and Visualization of the Immaterial

Simulation--in opposition to representation--involves the ‘creation’ of a behavioral model of a building. Models of real world phenomena are translated into mathematical or physical abstractions of specific performance criteria. The aim of simulation as scientific visualization is to make the immaterial quality of space visible in this case its property to enhance air movement. “Scientific visualization of processes which are usually not perceivable by the eye, are made visible through a color coding.”

Air Motion in the Viipuri Library

The Viipuri library by Alvar Aalto is one of a few buildings in the history of Modern architecture where a sketch has been preserved which tries to visualize the air movement anticipated in the building.23

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23 Printed with permission of the Alvar Aalto Archive and Museum Jyväskyla, Finland.
Current research work\textsuperscript{24} shows that the relationship of spatial flow and material flow is extremely complex and not symmetrical. The simulation of 10 minutes took one week of computational time. In spite of huge developments in hardware and software, computational fluid dynamics (CFD) is currently not a viable option as a design tool for shaping spaces of air flow, an architecture which enhances the movement of air. Experience and intuition are still the designer’s most important tools.

**Drawing Air Movement**

Intuitive approaches address the design of space either as a geometrical composition or as sensual phenomena but a combination of both is necessary. The ongoing research project in which the author is involved investigates the complex relationship between spatial composition in free-flow open space typology and thermal and climatic conditions related to air flow within buildings. The overall research starts at an environmental re-reading of selected architectural icons of modernism, which elaborated the free-flow open section using analytical drawing and visualizations of air flow simulation in computational fluid dynamics (CFD). The most important architectural strategy to enhance the interior climate utilizes the properties of air movement in free-flow open spaces.

**The Movement of the Hand as a Tool**

As stated earlier, visual culture dominates architectural production. An overemphasis is placed on digital media. The discipline favors the design integration of digital image production over the integration of heating, cooling or even lighting. Consequently, it is difficult to include the ‘way we do things’ into the design process. With a change in attitude design should still take advantage of visual representation tools but explore the tools to challenge how parameters other than the visual can contribute to form making processes.

![Figure 10: Preliminary Studio Design Sketch Depicting Hand Movement While Unfolding an Umbrella, 1997. Photo: the Author](image)

Before gaining understanding, learning starts by experience and understanding is supported by making. Thus in order to fully integrate issues of environmental performance into the design process the distinction between the ART of architecture and the MAKING of buildings need to be questioned. The goal would be to better understand thermal performance and natural ventilation as an energy-efficient strategy and integrate those energy flows into the architectural design. This integration needs to develop in four stages: environmental experience, concept understanding, critical reflection and design process integration.

The mathematical equations for heat transfer are descriptions of physical phenomena gained through observation and can be treated like compositional relationships. Learning
happens in the process of experiencing and observing how mathematics and physics can
describe the environmental phenomenon of the built environment--of the home, classroom
or town. Learning about environmental forces starts by understanding how a built form reacts
to the forces and mediates these forces between the perceiving, experiencing and inhabiting
body and the space surrounding it. Designing with all senses in mind leads to architecture
which is not static but performance based--or fluent--and thus changes and adapts with light,
sound, season or thermal flux. But those forms and spaces do not necessarily need to look
fluid.25

Experience and Conceptual Understanding of Flows

For thousands of years the hand has been the measure and scale for all architectural tools
and devices of production. The eye acted as the critical agent of the hand. In the process of
architectural design the hand can best depict the effect of forces on the body, the behavior
of the body. Space is considered a social and geographic construct, produced by society,
rather than an absolute given. This understanding has not reached the understanding of its
environmental conditions. These are still considered as given by ASHRAE26 and not critically
reflected as a negotiable and adjustable standard although the neutral and homogenous air
has yet to be achieved--much to the frustration of engineers. Spaces are usually warmer at
the top and colder at the glass surfaces; there are desired or undesired drafts and odors and
sounds, which expand in waves within a space. Those elements create space as much as the
physical boundaries do and design practice should adjust to this shortcoming.

Therefore this final section will showcase examples of how to integrate knowledge about
bodily behavior related to environmental forces and its visualization for enhancing a design
practice. This practice, ideally, is one where the ecological debate about energy efficiency,
sustainability and climate design is connected to the cultural and debate about perception,
typologies and ‘Gestalt’, and the idea of appearance--thus travelling the Northwest passage,27
mediating between experience and measurement, moving from geometry to perception, at-
mosphere to typology, transparency to structure, and technology to desire. All are critical
parameters in the creation of space as a cultural artifact that address all senses28.

A process-oriented design practice supports the shaping of the form and function of the
design by understanding the environmental behavior of space and its agents. The design
representations and visualizations of phenomena all have one method in common: the
movement of the hand while drawing and capturing fluid motion of material which changes
phase and becomes solid, taking a shape or form. Those drawings and objects indicate a
close link between the hand movement, the matter, which is formed to visualize the motion
and the eye as a critical and reflective agent to the intuitive searching hand.

Thermal comfort in an architectural interior is usually created by conditioning the whole
air volume within a space. Due to this overwhelming and often unnecessary use of air-con-
ditioning in the United States where the air is sealed and forced into hidden ductwork, the

126, where the space is fluid, but a huge air duct system needs to adjust the interior climate, which is hermetically
sealed from the outdoors, thus not allowing any flux between the two climates.
26 ASHRAE Inc. “ASHRAE Standard 55—thermal environmental conditions for human occupancy”. Atlanta:
28 Howles, David (ed). Empire of the Senses, the sensual culture reader, New York: Berg Publisher 2005.
natural flow of air is often ignored in studio design. The selected projects show approaches of students to the visualization of air flow due to wind, temperature difference, sound or convective flows, revealing volatile qualities so important to comfortable and delightful spaces.

**Flow of Tempered Air**

A thermal bath is molded into the landscape in the shape of a vessel facilitating the stack effect due to hot air rising. Circulation and spatial form are intrinsically related to the intuitive understanding of moving warm air.

![Figure 11: Thermal Bath Studio Design by Eric Smith, Architecture Graduate Studio by the Author at ISU 2007](image)

**Expansive Flow of Sound**

The project shown depicts a transformative process of carving space to the tune of a Bela Bartok concert piece. Sound waves are transformed into light patterns which are drawn in charcoal and carved into a clay sculpture, which serves as the basis for the ceiling of a very special concert hall.

![Figure 12: Studio Project by Nils Schincker on Music by Bela Bartok, Technical University Berlin 1995, Photo: Ulrike Passe](image)
Radiant Heat of Thermal Mass

The change of seasons in Rome is a delayed process due to the thermal mass of the stonewall enclosing most of the space from ancient to Baroque and Classical buildings. In winter the church interior is still slightly warmer than the outside as the thermal mass of the walls captured the heat of the summer. When spring turns into summer, the interior of the church remains cool retreats from the heat of the sun. This paper model depicts this phenomenon as perceived in the vaults of Borromini’s S. Carlo alle Quatro Fontane.

Figure 13: ISU Rome Studio Passe; Spring 2006

Capturing the Warm and Cold Winds of Rome

The first model is crafted after the void created by the ventilation opening in the crypta of S. Carlo alla Quatro Fontane, a form shaped after the Venturi effect to accelerate wind velocity.

Figure 14: ISU Rome Studio Passe, Spring 2006

The other model is created after a volatile effect by the seven winds, which shape the specific quality of the Roman climate and weather. The wax casting of silk cushions captures the
ephemeral quality Rome atmosphere to shape canopies for a fresh produce market in open air. The final image captures the volatile movement of fashion.

Figure 15: ISU Rome Studio Passe, Spring 2006: Leah Rudolphi

Figure 16: ISU Rome Studio Passe, Spring 2006: Justin Burnham

Summary and Conclusion

In regards to global warming and depleting resources, the current urgency to change how we build demands a better or even different integration of environmental forces in the design process. Given these critical demands of green design, design practice and principles are about to change. Space cannot be considered neutral without qualitative properties. Form and its sensual content should be developed based on a holistic conceptual understanding of space and materials with all their complex environmental, phenomenological and sensual properties. Visualization and awareness of all sensual qualities of space is thus the crucial starting point towards a holistic architectural design practice.
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About the Author

Ulrike Passe

My compass for research, teaching and practice is the Passage du Nord-Ouest as taken by Michel Serres to describe the passage between the humanities and science. Through the course of my career I went from speculative urban concept designs for the newly unified Berlin to culturally and socially relevant communal architectural projects, which I worked on as a project architect. I then taught undergraduate design and structure studios at the Technical University in Berlin, where I also carried out a research project in widespan steel construction and got more and more interested in the architectural space as a technology for more energy efficiency in building and climate design. I ran my own practice in Berlin, Germany, was involved in higher education policy at the Fachhochschule in Potsdam. I work on a research agenda at Iowa State University for the study of free-flow open space and air flow intertwined between culture, climate and nature as in the work of Alvar Aalto, to see materiality and construction, energy efficiency and sustainability in a critical cultural context. I am teaching Design in the Graduate School and start a course on Environmental Forces in Architecture.
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